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Review & Analysis

Status Update of Alternative Control and Display Technologies, Volume I: Final Report

Prepared for: Human Research and Engineering Directorate
U.S. Army Research Laboratory
Aberdeen Proving Ground, MD 21005-5425

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13. ABSTRACT ***(Maximum 200 Words)***

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An Alternative Control and Display Technology Matrix was developed to compile and summarize the subject matter expert/source survey results. This matrix contains technology descriptions, point of contact and/or web source information, estimated technology maturity/availability level, and perceived benefits to the warfighter as stated in the technology description or subject matter contact results. In addition, web sites, papers, or other sources identified that may be of interest for further independent investigation are listed.

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EXECUTIVE SUMMARY

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With alternative controls and displays the steps from intention-to-action-to-feedback will typically be shortened and more direct. In fact, the distinction between controls and displays is becoming increasingly artificial. The same device may have both a control and a display function, and they may have to work together synergistically to aid user performance. Some future technologies may be so transparent in their design or application as to not be consciously perceived, but merely regarded as aspects of normal "conversation" with the system.

Of the more mature alternatives, Automatic Speech Recognition (ASR) and head-based technologies are both in operational and experimental use, depending upon the level of sophistication of the technology. Both are technically mature enough now for full operational use, with research on the next generation, higher capability, systems in progress.

Eye-based control is laboratory mature and used for assessing eye movement in simulators, and with further development, has the potential to integrate effectively in the operational environment with head- and voice-based control. It may enable a range of potentially useful explicit and implicit control functions. The technology is not yet mature enough for the full operational environment, but the necessary advances can probably be made in the near (two to four yrs) to midterm (four to seven yrs). Gesture- and biopotential-based (EEG, EMG) technologies are the least mature. Application of these technologies is just beginning in the commercial entertainment environment, but they provide much potential for future generations of Army systems (2020).

Virtual retinal displays (VRD), tactile vests, and volumetric displays are also discussed. VRDs and tactile vests are somewhat mature technologies being implemented in a limited fashion or being demonstrated operationally within the Department of Defense (DoD). Volumetric displays appear useful in presenting large volumes of three-dimensional data for Command and Control (C^2), but have limitations that currently prevent their effective use in Army ground-based and airborne crew stations.

It appears a noticeable amount of work remains to be done by researchers and engineers both in the human factors and engineering domains to prove and provide the benefits that might be gained by integrating alternative technologies into future crew station environments. Achieving a meaningful and intelligent implementation of these technologies will require a synergistic effort involving research labs, system manufacturers, and equipment makers.

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This work was supported by the U.S. Army Research Laboratory, Human Engineering and Research Directorate (HRED) under the auspices of the Human Systems Information Analysis Center (HSIAC) Program Office, Contract No. SPO700-98-D-4001; Task No. 8027. HSIAC would like to thank and acknowledge Mr. Paul H. Cunningham as Program Manager and the contributions of Dr. Joe McDaniel (AFRL/HECI; HSIAC COTR), Dr. Michael Fineberg (HSIAC Chief Scientist), and RoseAnn Venis (Technical Editor) during the review process. In addition, Judith Hecht provided excellent support in conducting the required commercial and government literature searches for this project.

NOTICE

This report comprises two volumes. Volume I (HSIAC-RA-2001-001) is the final report on alternative controls and displays, accompanying appendices and noncopyrighted literature search results. Volume II (HSIAC-RA-2001-002) contains pertinent copyrighted citations extracted from commercial databases.

DISCLAIMER

The views, opinions, and/or findings contained in this report are those of the authors and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

ACRONYMS

3D	Three-dimensional
ARL	Army Research Laboratory
ASR	Automatic Speech Recognition
C^2	Command and Control
CTF	Contrast Transfer Function
DHM	Dexterous HandMaster™
DoD	Department of Defense
DROLS	Defense RDT&E On-line System
DTIC	Defense Technical Information Center
EEG	Electroencephalographic
EMG	Electromyographic
HFE	Human Factors Engineering
HITL	Human Interface Technology Laboratory
HMDs	Helmet Mounted Displays
HOTAS	Hands On Throttle And Stick
HPS	Head Pointing Tracker Systems
HRED	Human Research and Engineering Directorate
HSIAC	Human Systems Information Analysis Center
IPE	Individual Protective Equipment
LOS	Line-of-sight
NASA	National Aeronautics and Space Administration
NAMRL	Naval Aerospace Medical Research Laboratory
NATO	North Atlantic Treaty Organization
R&A	Review & Analysis
R&D	Research & Development
RTO	Research and Technology Organization
SME	Subject Matter Expert
TAG	Technical Area Group
TSAS	Tactile Situational Awareness System
USAARL	U.S. Army Aeromedical Research Laboratory
VRD	Virtual Retinal Display

1. INTRODUCTION

1.1 BACKGROUND

This Human Systems Information Analysis Center (HSIAC) Review & Analysis (R&A) provides support to the Human Research and Engineering Directorate (HRED) of the U.S. Army Research Laboratory (ARL) and addresses human systems integration research associated with alternative information processing controls and displays that might be suitable for use in future Army ground-based and airborne crewstations.

The integration of advanced technologies into Army ground-based and airborne systems has the potential for making soldier operation of these systems more efficient and effective, as well as providing the soldier with greater situational awareness at lower levels of cognitive workload. Some of these technologies, known as alternative control and display technologies, involve the aiding or augmenting of information to and from the soldier by nontraditional modalities so they can respond more quickly to the demands of the battlefield.

1.2 PURPOSE

ARL-HRED performs research exploring the integration of advanced information technologies within Army crew stations. However, ARL-HRED needs to be appraised of alternative control and display technologies and identify when they might be available for test and integration activities. Therefore, this effort is designed to provide an overview of the alternative control and display research literature to include (1) technology descriptions, (2) assessments of advantages and disadvantages those technologies may provide to Army systems, and (3) estimates of technology availability and maturity for operational use.

1.3 SCOPE

This effort has been designed to determine the status and availability of alternative controls and displays for implementation within Army ground-based and airborne crew stations. To that end, this investigation provides a broad baseline of information on speech-based/auditory, eye- and head-based, gesture/tactile, and biopotential technologies. Where the literature was lacking and within time and budgetary constraints, subject-matter experts were contacted to determine technology status and assess its relevance to the improvement of soldier performance.

1.4 OVERVIEW

A brief description of the research method used to identify and analyze alternative control and display technology information is provided in Section 2, METHOD. The relevant findings are presented in Section 3, RESULTS. Within Section 3, the findings are organized as follows:

Section 3.1 RATIONALE FOR ALTERNATIVE CONTROL/DISPLAY TECHNOLOGIES
Section 3.2 TECHNOLOGY DESCRIPTIONS
Section 3.3 EXPECTED BENEFITS
Section 3.4 SURVEY RESULTS

Section 4, CONCLUSIONS, is followed by references, recommended readings and appendices containing additional detailed information.

2. METHOD

A keyword list and search strategy (Appendix A) was developed and a search of both government and commercial literature databases was conducted to identify relevant information. The search strategy was employed by professional database researchers using the following in-house, government and commercial databases:

- Aerospace Database
- Applied Science and Technology Abstracts (1983-Present)
- Defense Technical Information Center (DTIC) Defense RDT&E On-line System (DROLS)
    - Research Summaries
    - Technical Reports
- Dissertation Abstracts
- Ei Compendex (1980-Present)
- Human Systems Information Analysis Center (HSIAC) Document Database
- U.S. Patents (1990-Present)

Search results produced over 1100 citations and abstracts, some of which were unrelated to the specific objectives of this effort. The abstracts were reviewed by HSIAC analysts to identify the most pertinent and selected documents were obtained to use as source material in the preparation of this report.

Sections 3.1-3.3 of this report rely especially heavily on material drawn from a chapter on *Nonconventional Controls* by McMillan, Eggleston, and Anderson (1997) in the Handbook of Human Factors and Ergonomics (Salvendy, 1997) and a NATO Research and Technology Organization (RTO) report (NATO, 1998) entitled *Alternative Control Technologies: Human Factors Issues* assembled to support a Working Group 25 Lecture Series under the sponsorship of the Human Factors and Medicine Panel. These documents provide excellent technology summaries and succinctly address the human factors and engineering implications of incorporating advanced, alternative controls and displays into warfighter crew stations.

An internet search was also conducted and key subject-matter experts were identified and contacted to capture commercial, academic, and laboratory research and development efforts not yet published in the open literature. Further, members of the Controls and Displays/Voice Interactive Systems Human Factors Engineering (HFE) SubTAG (Technical Area Group) were contacted and asked to provide input regarding ongoing research and development in the area of alternative controls and displays. Results of this effort are documented in Section 3.4, SURVEY RESULTS, and supported the development of the Alternative Control and Display Technology Matrix found in Appendix B. Relevant citations extracted from non-copyrighted literature databases are found in Appendix C.

3. RESULTS

3.1 RATIONALE FOR ALTERNATIVE CONTROL/DISPLAY TECHNOLOGIES

Future Army crew systems will inevitably incorporate more complex technologies to cope with increasingly demanding operational scenarios. As crew system capabilities continue to increase through the use of more sophisticated sensors and software, there will need to be an equivalent advance in the way the warfighter interfaces with the systems to enable efficient information exchange and control between the operator and future generations of Army ground-based and airborne crew stations.

Physically and cognitively demanding operations in the current generation of fixed and rotary wing aircraft, particularly at night and in poor weather, have increased the need for more "eyes-out" operations, reducing the time for assimilation of information from head down displays/controls. Progress has been made toward the assimilation of visual display data through Helmet Mounted Displays (HMDs) and time reductions in switching operations have been achieved by the use of the Hands On Throttle And Stick (HOTAS) concept—ensuring that the pilot has no need to move his or her hands from the primary aircraft controls during high workload periods. However, next generation Army crew stations aspire toward implementing alternative control and display technologies to provide a more natural interface between the operator and the system (NATO, 1998). The following sections will define and describe some of these alternative technologies and their method and suitability for implementation in the operational environment.

3.1.1 Definition

Alternative information control and display technologies may be regarded as any concept that has not been commercialized or gained wide acceptance in the military operational environment. However, McMillan et al. (1997) define them as technologies "...that do not require a direct mechanical linkage between the user and the input device" (p.730). Therefore, with alternative controls and displays the steps from intention-to-action-to-feedback will typically be shortened and more direct. In fact, the distinction between controls and displays is becoming increasingly artificial. The same device may have both a control and a display function, and they may have to work together synergistically to aid user performance. Some future technologies may be so transparent in their design or application as to not be consciously perceived, but merely regarded as aspects of normal "conversation" with the system.

3.1.2 Paradigms

The following sections provide some understanding of the interface design paradigms used to structure and guide alternative control and display research, development and implementation.

3.1.2.1 Substitution

The most straightforward path of alternative technology insertion is to replace a conventional control or display device with a nonconventional one. Within this paradigm, the goals for the new device remain unchanged from the original ones, only the method of implementation is changed.

3.1.2.2 Supplemental

Another interface development paradigm involves adding alternative technologies to provide additional control or display paths for the user when, for example, a new task is being introduced.

These technologies may be integrated with conventional controls to increase their range of functionality or be used as backup devices for built-in redundancy in case of primary control/display failure or during periods of peak operational workload.

3.1.2.3 Transparent Interface

Alternative technologies that support direct manipulation of system elements by the warfighter to accomplish a task may be referred to as "transparent" in nature. A transparent interface develops when the line between control and display becomes "blurred" and is no longer apparent to the operator.

3.1.2.4 Intelligent Interface

An intelligent interface is one that can interact with the user at the knowledge level (McMillan et al., 1997). Abstract commands, interpreted in a context sensitive manner by the interface, exercise ultimate control for lower level actions. In this case, control and display actions will not be directly manipulated by the user, but may instead be inferred or interpreted by the system based on operator actions and the corresponding sensor input from the operational environment.

3.2 TECHNOLOGY DESCRIPTIONS

The following sections contain a high-level review of the alternative technologies most frequently cited as showing promise for implementation in the military operational environment.

3.2.1 Speech-Based/Auditory Technologies

Speech-based/auditory technologies are the most mature technologies discussed in the literature and probably represent the lowest risk alternatives for system control and information display.[1] With the use of voice command as control input to the system, the problem of memorizing switch or button positions in a HOTAS paradigm is reduced, with only the lesser problem of remembering the functions remaining. In practice this reduction in memory demand should significantly reduce errors, especially during periods of peak workload. Due to the remaining limitations in the technology, however, and the expectations of users for highly accurate, robust, and reliable systems, applications of this technology in the military operational environment are only recently becoming more widespread. Research work is now taking place for the next generation of systems.

3.2.1.1 Automatic Speech Recognition (ASR)

ASR systems map an input speech waveform to its corresponding text as stored in the system database. While a wide variety of specific components and processes have been used, all ASR systems consist of combinations of the following:

- Signal acquisition—microphones of various styles and frequency responses.
- Signal processing—digital signal processing algorithms that identify or quantify the speech signal.

[1] It may be argued that eye-/head-based technologies are already implemented in many operational military crew stations. Therefore, they represent a more mature technology. However, speech-based/audio technologies are commercially available and implemented across a wider variety of applications.

- Pattern matching—algorithms that transform the processed speech into a text string of the recognized speech.
- Feedback—visual or auditory changes in the display or system status that indicate a control command was received and implemented as intended.

ASR systems are often subdivided into classes according to the problems they address (Figure 1). The first subdivision is based on number of speakers a system will recognize. Speaker-dependent systems generally recognize speech from only the speaker that "trained" the system. Speaker-independent systems recognize speech from many speakers.

The next subdivision is based on how the system handles word boundaries. Isolated word systems require a 100-250 millisecond pause between spoken words for accurate recognition. Connected word recognition systems require a very short (<100 millisecond) pause between words. Continuous speech recognition systems require no pause between words and can generally accept fluent (i.e., conversational) speech.

Finally, a subdivision is based on the size of the vocabulary that the system is able to recognize: small (< 200 words), large (1000 –5000 words), very large (5000 words or greater) or unlimited (> 64,000 words). Speech recognition performance for small and large vocabulary systems is generally adequate for benign (i.e., quiet office) environments. However, dramatic changes in the acoustic environment are likely to cause a degradation in system performance.

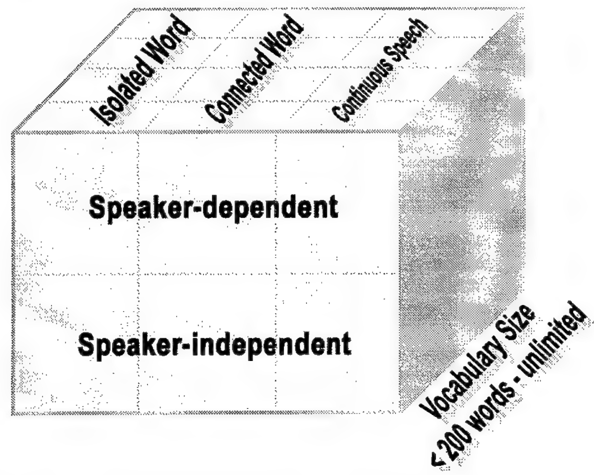

Figure 1. Subdivisions used to classify ASR systems

The answer to which combination of the above characteristics is best depends on the particular application and the characteristics of the user, task, and environment. Figure 2 is a decision guide, helpful for evaluating the best combination of characteristics.

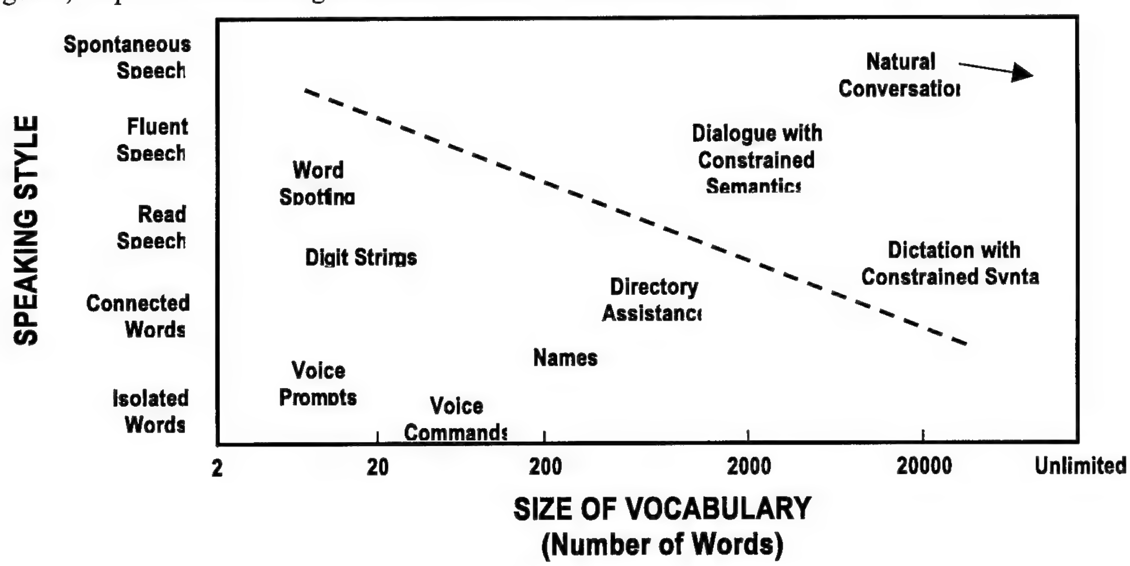

Figure 2. Different speech recognition tasks shown in a two-dimensional space: speaking style and vocabulary size. (McMillan et al.,1997; as adapted from Atal, 1994)

Applications that can be accomplished with current technology are shown to the left of the dotted line, while applications to the right require additional research and development before they will be practical for operational environments.

3.2.1.2 Three-dimensional (3D) Acoustic Display

Attention has been devoted to the use of nonspeech audio as an interface medium since auditory signals are detected more quickly than visual signals and tend to produce an alerting or orienting response (e.g., cockpit alerts, warnings, and cautions). The three-dimensional (3D) acoustic display is a means for accurately transferring information to an operator using the auditory modality; it combines directional and semantic characteristics to form naturalistic representations of objects and events in remotely-sensed or simulated environments (Wenzel, 1991).

A 3D auditory display may be most usefully applied in contexts where the representation of spatial information is important, particularly when visual cues are limited or absent and workload is high. Such displays can potentially enhance information transfer by combining directional with iconic information to represent dynamic objects in the interface. Although the technology could likely stand alone in some applications, it is primarily envisioned as a component of a larger multisensory (e.g., visual, tactile, auditory) environment.

3.2.1.3 Design Methods and Principles

McMillan et al. (1997, p. 738; as adapted from Simpson, McCauley, Roland, Ruth, & Williges, 1987) and Wenzel (1991, p. 4) present the following general design guidelines for ASR and 3D acoustic display systems that may be valuable for ARL/HRED researchers investigating the implementation of these technologies into current and future Army crew stations:

1. When using speech-based control, expect the greatest payoff in task performance speed and accuracy for complex information entry tasks that must be performed in conjunction with other manual or visual tasks.
2. The selection of speech-based control should be based on an analysis of the application task requirements. When designing the vocabulary for the recognition system, use terminology that is familiar to the users and avoid the use of acoustically similar words.
3. Users should be trained to improve their pronunciation and microphone usage when possible.
4. Performance of the human-machine system should be measured in terms of operationally relevant measures such as system response time, system accuracy, and user acceptance.
5. Feedback should be provided so that the user is aware of the recognition results or the system response to the input. The more immediate the feedback, the less confusion as to source of the error. The modality of the feedback should be compatible with the demands of the task.
6. If errors occur, a correction capability should be provided that minimizes demands on the user and maximizes system throughput.
7. Acoustic displays must adequately reproduce the audible spectrum in frequency resolution and dynamic range.
8. Information must be presented accurately in three spatial dimensions.
9. Displays must be capable of representing multiple sources of auditory information that can be either static or moving.
10. Auditory information presentation must be real-time and interactive; that is, responsive to the ongoing needs of the listener.

11. The technology must be head-coupled to provide a stable acoustic environment with dynamic cues appropriately correlated with head motion.
12. The technology must be flexible in the type of acoustic information that can be displayed; for example, real environmental sounds, acoustic icons, speech, or streams of multidimensional auditory patterns or objects. Durlach and Pang (1986) have also proposed that auditory displays be used to enhance (artificially magnify) the perceptual capabilities to localize and identify normal sounds (i.e., super localization).

Ultimately, speech-based control and 3D acoustic displays should be designed according to accepted human factors principles, i.e., to meet the need for ease of use, transparency of control, and adaptability to changing operational scenarios and user input styles. In addition, it would be wise to retain some redundancy ("Supplemental" paradigm) in any system to allow operation by either manual or ASR control—depending upon mission phase or task demands.

3.2.1.4 Future Research and Development

Continued research is required to improve ASR robustness to multiple speakers, new dialects, and microphone characteristics. Integration of automatic lip reading and speech-based control has been attempted as a means to improve speech recognition in noisy environments, but performance is still lacking (McMillan et al., 1997). This would not be appropriate for the warfighter wearing individual protective equipment over the face (e.g., respirators). Further, speech recognition performance for very large vocabularies does not yet appear adequate for application in military operational environments.

Another issue that must be addressed is the ability to operate speech-based controls in multitask, high workload environments that include the effects of task loading and other physical stressors on speech and their resultant impact on speech recognition performance (Rajasekaran & Doddington, 1986; Stanton, 1988). While much research has been conducted in this area over the last decade (e.g., ITT's Command Voice! Family of Tactical Voice Recognition Systems appears to provide state-of-the-art speech processing technology in real-time. High performance voice recognition and control capability for tactical application in high noise and high stress environments.), it appears continued research is needed to further assess and reduce the impact of these factors within the military operational environment.

The reason for errors such as front-back confusions (responses which indicate that a sound source in the front hemisphere, usually near the median plane, is perceived to be in the rear hemisphere) within the 3D acoustic environment is not completely understood either. Research indicates these errors are probably due in part to the static nature of the laboratory presented stimulus and the ambiguity resulting from the so-called cone of confusion (Mills, 1972; Wenzel, 1991). However, Warren, Welch, and McCarthy (1981) note that it may be visual dominance playing a role in auditory localization. That is, given an acoustic stimulus in the absence of any obvious visual phenomena, the perceptual system may be invoking a heuristic that assumes the source is behind the listener where it can't be seen.

Finally, refinements in the area of "real time" control systems (Wenzel, Whightman, & Foster, 1988), training techniques and multisensory display approaches (Wenzel, 1991) should be considered for further investigation.

3.2.2 Eye- and Head-Based Technologies

The emergence of flight worthy HMDs and the development of accurate flight worthy Head Pointing Tracker Systems (HPS) has facilitated the development of new target sensing, alerting, cuing, designation, engagement and enhanced weapon delivery methods to be implemented in the

modern Army crew station. Eye tracking technology, however, is relatively mature only in the research and development domain. No currently available eye tracking systems appear to be dependable enough or automatic enough for operational applications, nor are there any current systems identified as being available in a completely militarized configuration.

Magnetic, ultrasonic, and electro-optical technologies are now employed instead of the direct mechanical connections found with the first head tracking system designs.[2] Some of the performance parameters, as well as the strengths and weaknesses of each approach, are summarized in Table 1.

Table 1. Performance parameters, strengths and weaknesses of eye-/head-based technologies (adapted from McMillan et al. 1997, p. 740)

Tracker Technology Category	Range of Angular Inputs (RMS	Accuracy Range (milliradians) (RMS)	Strengths	Weaknesses	Possible Interference Sources	Development Status
Electro-optical using rotating IR beams or planes of light	AZ: ±180° EL: ±70° Roll: ±35°	3 to 10	Availability	Helmet weight (12 oz) Reliability of moving parts No head position information	Helicopter rotor chop Sun modulation	Production (F-4 Phantom, AH-64 Apache, and A-129 Mangusta)
Electro-optical using LED arrays	AZ: ±180° EL: ~±60° Roll: ~±45°	1 to 10	Simple installation Minimum added helmet weight High accuracy	Coverage Limited motion box Covertness	Reflections IR energy sources	Prototype
Electro-optical using videometric techniques	AZ: ±180° EL: ~±60° Roll: ~±45°	2 to 15	No added helmet weight	Limited motion box Helmet surface integrity	Reflections IR energy sources	Prototype
Ultrasonic concepts	AZ: ±180° EL: ~±90° Roll: ~±45°	5 to 10	Minimum added helmet weight	Partial blockage Stray cockpit signal returns Accuracy No head position information	Air flow and turbulence Ultrasonic noise sources Multi-path signals	Prototype
Magnetic concepts AC or DC	AZ: ±180° EL: ~±90° Roll: ~±180°	1 to 8	Very low added helmet weight Simple mechanization Good noise immunity High accuracy Very large motion box	Ferromagnetic an/or metal conductive surfaces cause field distortion (cockpit metal, moving seat, helmet CRTs)	Changing locations for metal objects Rarely—magnetic fields	AC system in low-rate production for AH-66 Comanche Several commercial variations of AC and DC designs in production

As shown above, only the electro-optical system using rotating infrared beams and the magnetic tracking systems are currently in production. Although mature as laboratory research instrumentation, the current generation of devices has probably not yet reached the level of true practicality for the Army crew station environment.

One technical challenge to overcome is to track the head and eyes with the speed and accuracy required for natural human-machine interaction. The head can be positioned with high accuracy and is more amenable to precise conscious control than the eye. Using head-based control alone, however, can lead to frequent and tiring motions that are unnatural to the user. Acceptance

[2] Detailed descriptions of each approach are provided by Ferrin (1991). Kocian and Task (1995) examine the factors to be considered in selecting a particular measurement approach.

problems seem likely if the user is required to make frequent head movements when eye movements would normally be employed.

Eye tracking has great potential within the conventional crew station. For example, this technology may be used for explicit control such as designating targets in the external world (e.g., for off-boresight weapons) and selecting items on crew station displays. It may also be used for implicit control functions such as providing context information for voice or gesture controls, or allowing enhanced resolution of just the local area (area of interest) being viewed within a display. By the use of eye tracking it will be possible to reposition the cursor by the combination of fixing the eye on the required point and commanding the reposition with either a manual control or by the use of a voice command. This method of interaction has the potential to provide significant reductions in warfighter workload.

In comparison with head pointing alone, eye-based control offers potential advantages of speed, ability to cover a wider angular envelope, and the possibility of less performance deterioration under turbulence-induced vibration or during high-g combat maneuvering.

3.2.2.1 Design Methods and Principles

There are a good deal of data to assist in the design of eye- and head-based command systems. One set of tools often used to compare various control techniques are movement time models such as Fitts' Law (Fitts & Peterson, 1964). These models attempt to capture the speed-accuracy trade-off that is a necessary component of precision control activity.

In addition to the movement time prediction models, McMillan et al. (1997) present the following guidelines for ARL/HRED to consider when designing or evaluating a head-or eye-based control system:

1. The optimal gain for head-based control of a cursor on a video monitor will be in the range of 0.3-0.6 (Lin, Radwin, & Vanderheiden, 1992).
2. Head-based control which requires frequent, precise head movements to replace eye movements will be fatiguing and poorly accepted by users.
3. The use of long line-of-sight (LOS) dwell times, e.g., greater than approximately 300 milliseconds, eliminates the speed advantage of using eye-based control (Calhoun & Janson, 1991a).
4. The use of voice commands as a consent response in multisensory systems may be slower than manual button presses because of delays in the ASR system (Calhoun & Janson, 1991b).
5. Human performance with an eye-based control system will generally be better and more natural without direct LOS feedback (Borah, 1995; Calhoun & Janson, 1991a; Jacob, 1995). With a head-based system, LOS feedback is almost always required.
6. Processing delays and lags can be significant problems in head- and eye-based systems and need to be carefully managed during the interface design process. As a rule of thumb, the delay from head/eye movement-to-display-to-system response should be kept under 100 milliseconds. (p. 746)

3.2.2.2 Future Research and Development

The primary area in which eye-tracking hardware and software needs improvement is in the stability and repeatability of the measurements. Brief dropouts and jitter that may be acceptable in research environments will quickly erode user confidence in applied settings. Speed improvements are also needed both in the basic position measurement process and in the algorithms that transform these measurements for human-system interaction.

Seamless interpretation of head and eye movements to infer user interest, needs, and desires ("Intelligent Interface" paradigm) appears to be a much more powerful research and design path for this technology area. Development of multisensory interfaces to include head and eye inputs should serve to expand the bandwidth (throughput) of human-system communication. This approach may actually help to constrain overall system cost. For example, by using eye and gesture as redundant pointing mechanisms, lower precision may be acceptable in each measurement subsystem. Similarly, if speech recognition is used to issue specific commands while the referents are specified with eye and gesture, smaller vocabularies will be required—expanding the life-span of currently fielded ASR systems.

3.2.3 Gesture/Tactile Technologies

Two principal measurement systems are used in gesture recognition: (1) systems that measure the position of limbs and body segments in 3D space, and (2) systems that measure the joint angle directly (Sturman & Zeltzer, 1994).

Glove-based techniques are the current method of choice for hand and finger joint angle measurement. Three glove systems are widely available at present, the DataGlove™, the Dexterous HandMaster™ (DHM), and the CyberGlove™. The DataGlove™ is no longer produced, but is still available in many laboratories. The characteristics of these three devices are summarized in Table 2. As shown here, the DHM™ and CyberGlove™ appear to have the accuracy required for complex posture and gesture recognition.

Table 2. Glove-based technology characteristics (adapted from McMillan et al., 1997; p. 751)

	Construction	Sensing System	Accuracy
DataGlove™	Cloth glove with fiber optic bundles attached to the back	Joint bending sensed by attenuation of transmitted light. 10 flex sensors measure lower two joints of each finger and two joints of thumb. Operates at 60Hz. Magnetic tracker can be attached to back of glove.	Rated at 1°, but 5-10° is typical. (Quam, Williams, Agnew, & Browne, 1989; Wise et. al., 1990)
Dexterous HandMaster™	Exoskeleton-like device	Hall Effect sensors used as potentiometers, 20 sensors measure each finger joint, finger abduction and complex motion of thumb. Operates at up to 75Hz with 20 sensors. Magnetic tracker can be attached.	Better than 1° (Sturman & Zeltzer, 1994)
CyberGlove™	Cloth glove with foil strain gauges sewn into the back	18 or 22 sensor models measure finger and thumb joint angles, finger and thumb abduction, palm arch and wrist bending. Operates at up to 149Hz with 18 sensors. Magnetic tracker can be attached.	Better than 1° (Sturman & Zeltzer, 1994)

Feedback requirements for applications that involve simulated object manipulation, vehicle control, and robot operations are still the subject of much research and development. The importance of simulated tactile and kinesthetic feedback depends on the specific task, the experience of the user, the availability of substitute visual and auditory cues, and the implementation of the artificial feedback. In many applications, however, the only feedback that is provided is the system's response to a recognized gesture.

Pneumatic, shape-memory materials and vibrotactile technologies have been used for providing tactile feedback. Experiments have also been performed using hydraulic systems, electric stimulation of the skin or even direct neuromuscular stimulation. The currently available devices are few and this area is still mostly a research domain with one notable exception being the Tactile Situational Awareness System (TSAS) under development by the Naval Aerospace Medical Research Laboratory (NAMRL). This system is discussed in more detail in Section 3.2.5.2.

Force feedback systems can use electric, hydraulic or pneumatic technologies. They were first applied to telemanipulation arms. Increasing miniaturization has allowed the incorporation of such systems into gloves and joysticks. Despite this progress, the main disadvantage is that most of these systems remain bulky and intrusive, which prevents their use in transportable devices or the already space constrained environment of ground-based and airborne crew stations.

3.2.3.1 Design Methods and Principles

While this area of research is still relative immature, McMillan et al. (1997) have suggested some general design guidelines that ARL/HRED may find applicable:

1. Gesture-based control should offer learning and performance advantages if the task is based on a set of already learned signs or signals. Glove-based translation of American Sign Language is an example.
2. Gesture-based control should offer learning and performance advantages if the natural coordination of the body can be employed to coordinate multiple degrees of freedom in the external device. Finger walking to control the locomotion of a legged-robot is an example (Sturman and Zeltzer, 1993).
3. Gesture-based control may be less effective than conventional control if the task requires high-resolution control of a single degree of freedom. At least two factors contribute to this: (a) conventional controls often have higher resolution than gesture-based devices, and (b) conventional controls often provide support and damping that is helpful in precision control situations. This may not be true for applications in which gesture affords more natural, user-scaled control location.
4. Gesture-based control may be less effective than conventional control if tactile and kinesthetic feedback are important for task performance.
5. Gestures should be concise and quick in order to minimize fatigue. High precision over a long period of time should be avoided.
6. Since most systems capture every motion of the user's hand, the controller must provide well-defined means to detect the intention of gestures. An example is Baudel and Beaudouin-Lafon's (1993) system for controlling computer-based presentations to an audience. Gestures are acted on only when the user is gesturing within the "active zone" of the projection screen. Gestures to the audience are not recognized. (p. 754)

3.2.3.2 Future Research and Development

The dynamic and often repetitive body movements involved in gestural communication can be a source of fatigue; thus it is important to use concise and simple-to-execute gestures. Further, high precision cannot be relied on over time, therefore systems must incorporate adequate or appropriate feedback to ensure that the desired gesture was produced.

Gesture input is made more difficult in a dynamic environment. As with head-based control, hand movements are impaired by G forces and by shock and vibration. Gesture-based input may also be impaired by the restrictions imposed with wearing individual protective equipment (IPE) such as chemical or arctic gloves. In addition, gesture input is characterized by large intra- and inter-subject variability. The difficulty of precisely reproducing a gesture is a potential source of precision and recognition problems. Differences between individuals suggest that some training of the recognition system is generally needed.

3.2.4 Biopotential Technologies

The notion of operating a device simply by thinking about the desired action represents the ultimate in intuitive control. The principal objective is to measure biopotential activity from the operator so that it can designate control actions or augment other control modalities (NATO, 1998).

3.2.4.1 Electromyographic (EMG)-Based

EMG-based control uses the electrical signals that accompany muscle contractions. The EMG signal results from the asynchronous firing of hundreds of groups of muscle fibers; controlling the force produced by the muscle contraction (Parker & Scott, 1986; Scott & Parker, 1988).

To date, the only sustained development within the EMG-based technology arena has been for prosthetic device operation. Most common prosthetic control algorithms employ simple on-off control based on the level or rate of change of EMG activity. For example, if muscle activity at one recording site exceeds some threshold, a prosthetic device moves. Above-threshold activity at another site causes the prosthetic device to move in the opposite direction. Movement stops when the EMG at both sites is below threshold.

Most current systems rely on visual feedback, or auditory and vibration cues from prosthetic motors, to provide this information (McMillan et al., 1997). Attempts to provide grip force feedback in prosthetic devices have most often employed vibratory or electrical cues proportional to grip force.

3.2.4.2 Electroencephalographic (EEG)-Based

EEG recorded from the surface of the scalp represents a summation of the electrical activity of the brain. EEG-based control is presently confined to laboratory systems and is based on one of two general approaches (McMillan et al., 1997):

1. The application of operant conditioning and biofeedback methods to enable the user to develop voluntary control of the magnitude of specific EEG responses or rhythms.
2. The application of pattern recognition algorithms to detect the EEG characteristics associated with specific body movements, eye fixations, or utterances and thereby predict a desired control action. No current algorithms attempt, or are capable of, thought or intent recognition. This approach requires no user training, but does require that the pattern recognition algorithms be trained with repetitions of the movements, fixations, or utterances. This process is directly analogous to the training of a speaker-dependent speech recognition system. (p. 758)

User feedback with EEG-based control systems has been implemented as both an inherent part of the task, e.g., movement of the display element being controlled by EEG, and as a separate display element when movement of the controlled element does not provide timely feedback.

Although current EEG-based control systems represent beginning steps toward a "thought-based" design approach, significant long-term development will likely be required to reach this goal.

3.2.4.3 Current Applications and Evaluations

Although current technology limits our ability to achieve such natural control systems, many practical biopotential devices have been designed and other promising technologies are being evaluated in the research community. For example, EMG-controlled prosthetic hands and wrists are of significant value for people with lower-arm amputations. This area represents the most significant real-world application of biopotential-based technology.

Biopotential-based control has been primarily employed as a substitute for conventional control methods. A NASA study (Clark & Phillips, 1988) investigated the possibility of using EMG control for robotic applications and found that direct use of the EMG signal was adequate for simple, single degree-of-freedom movements. More recent work (Junker, Berg, Schneider & McMillan, 1995) has shown that subjects can use both EMG and EEG signals extracted from electrodes on the forehead to track computer-generated targets with a cursor. Nelson et al. (1998) also found that, for discrete on/off responses, the EMG-EEG control scheme can achieve high accuracy with little user training and with reaction times comparable to manual switches.

In summary, one-and two-dimensional control and simple item selection have been demonstrated with current laboratory systems. The size, weight, and cost of these systems are not serious constraints, and learning EEG-based control does not appear to require any special skills or individual characteristics. However, until the flexibility, precision, and reliability of biopotential-based technologies can be increased to accommodate the demands of the military operational environment, current applications are probably limited to assistive devices for the physically challenged and input devices for entertainment systems.

3.2.4.4 Future Research and Development

Current biopotential-based systems could supplement a keyboard and mouse for basic computer input operations. In the military crew station, such discrete actions as radio frequency selection or multifunction display operation could be the probable next step. However, much remains to be investigated regarding the precision and reliability of biopotential-based control during high workload and multitask/multisensory environments.

3.2.5 Other Technologies of Interest

3.2.5.1 Virtual Retinal Display (VRD)[3]

The VRD is a personal display device that scans light directly onto the viewer's retina. In a conventional display a real image is produced. The real image is either viewed directly or, as in the case with most HMDs, projected through an optical system and the resulting virtual image is viewed. The projection moves the virtual image to a distance that allows the eye to focus comfortably. Because the VRD scans light directly on the retina, the viewer perceives a high-resolution, wide field of view image (the system has a sufficient bandwidth to handle displays with well over a million pixels).

The field of view of the VRD is controlled by the scan angle of the primary scanner and the power of the optical system. Initial systems with greater than 60 degree horizontal fields of view have been demonstrated. Systems with 100 degree fields of view are feasible. See through systems will have somewhat smaller fields of view. Current see through systems with over 40 degree horizontal fields of view have been demonstrated.

Brightness may be the biggest advantage of the VRD concept. The current generation of personal displays do not perform well in the high illumination environments that can exist in airborne crew stations. Again, because the image is presented directly onto the retina there is no opportunity for the image to "wash out" in bright sunlight conditions.

Using seed funds from the Washington Technology Center the first VRD prototype was developed in the Human Interface Technology Laboratory (HITL) by Dr. Tom Furness, Joel Kollin,

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[3] Retrieved May 10, 2001 from Tidwell, M., Johnston, R. S., Melville, D., & Furness, T. A. The Virtual Retinal Display - A Retinal Scanning Imaging System. Seattle, WA: Human Interface Technology Laboratory, University of Washington (http://www.hitl.washington.edu/publications/p-95-1/ - 5)

and Bob Burstein. As a result of the work, a patent application was filed and the technology licensed to a Seattle based start up company, Microvision, Inc. Under terms of the agreement, Microvision funded a four-year effort in the HITL to develop the technologies that will ultimately lead to a commercially viable VRD product. This development work began in November 1993.

In 1999, Microvision delivered a prototype helmet mounted VRD to the U.S. Army Aeromedical Research Laboratory (USAARL), Fort Rucker, AL, to determine its capability to meet the RAH-66 Comanche HMD performance specifications (Rash, Harding, Martin, & Beasley, 1999). While falling slightly short of the performance expectations required by Comanche, the overall evaluation results indicated that VRD technology offers many advantages over more mature technologies in the area of luminance output, field of view, abberations and weight. Deficiencies were noted in the areas of luminance and contrast uniformity and contrast transfer function (CTF). In addition, a slow vertical drift was detected in the imagery. This drift could cause significant disruption to tracking and/or targeting performance if not corrected.

In summary, VRDs appear to offer much promise as alternative display technologies. With continued research the prospects of having systems ready for the operational environment appear very good for the near- to mid-term.

3.2.5.2 Tactile Vests

Lack of spatial orientation is blamed for the loss of about 30 lives and hundreds of millions of dollars worth of aircraft every year among U.S. forces alone. In conditions of poor visibility, the chance of becoming spatially disoriented increases exponentially. Unfortunately this bad visibility is apt to be encountered when precise aircraft movements are most needed, such as on search and rescue missions or combat sorties. Using night vision goggles and then being blinded by flares or gunfire is particularly distracting.

The Naval Aerospace Medical Research Laboratory (NAMRL) in Florida has focused on helping helicopter pilots to keep their aircraft on course. What the NAMRL scientists have come up with is the TSAS. The device employs an array of 18 pneumatic vibrators built into a vest and meant to be worn under a flight suit. Linked to a satellite navigation system and other instruments, the vest provides altitude, rate of movement and directional data through changes in the intensity and frequency, as well as the direction, of the vibrations.

All 18 of the vibrating buzzers can be triggered in different sequences. For example, a ripple of movement up a pilot's chest could mean that his aircraft's nose was lifting higher. A series of pulses increasing in tempo along his right ribs could mean that the chopper was drifting further and further to the right. Pilots who have tested the TSAS vest report that it makes stationary hovering much easier; even when they ignored the ground and their conventional instruments.[4]

This technology was recently purchased for use in the V-22 Osprey Program. Similar vibrating clothing and seats are being investigated for a wide range of military applications where spatial awareness is imperative. For fighter pilots, tactile stimuli could help them keep track of wingmen or draw attention to adversaries approaching from unexpected angles. Aquatic commandos like the U.S. Navy SEALS are also looking at the system to help them navigate better underwater. By extension, submarine commanders could use tactile stimulation to let them know if they are drifting off course or towards obstacles, or to keep them informed of other vessels or torpedo threats.[5]

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[4] Retrieved May 10, 2001 from *Tactile vest gives pilots seat-of-pants feeling.* By Bill Kaczor -- The Associated Press, Tuesday, May 18, 1999 (http://www.canoe.ca/CNEWSScience9905/18_pilots.html)

[5] Retrieved May 10, 2001 from HOW TOUCHING, Beyond 2000.com 30th Aug, 2000 (http://www.beyond2000.com/pda/story_729_pda.html)

3.2.5.3 Volumetric Displays

The problem of displaying 3D information in a useful, interactive format that enables faster and more reliable interpretation of data that are inherently 3D in nature has been faced for many years. In some applications 3D information data is mapped onto two-dimensional (2D) displays forcing the user to reconstruct a mental 3D view of the situation. Examples of this include air traffic control, undersea navigation, and medical imaging. Stereoscopic, autostereoscopic, and holographic-based 3D technologies have all addressed these applications with varying degrees of success (McAllister, 1993). One drawback to these methods is the limited viewing angle presented to the viewer. Related to this problem is the limited number of observers able to view the display at one time and, in some cases, the necessity of using special eye wear. These displays provide psychological depth cues but lack important physiological cues, especially motion parallax (Phillips, 1984; Williams, Wefer, & Clifton, 1992).

A volumetric 3D display presents an image in a true 3D volume that observers can view from any angle and can provide both psychological and physiological depth cues. The image points, or voxels, are physically formed in all three spatial dimensions that gives the viewer true depth cues (binocular parallax, accommodation, convergence) without the need for any special viewing aids.[6] Unfortunately, this technology is not yet developed enough to be valuable for the individual crew station environment that is the focus of this ARL/HRED effort. The space requirements for implementing this technology, not to mention the lack of data available to indicate its viability under shock and vibration, make it unlikely that this will be viable for the Army crew station environment in the near term.

3.3 EXPECTED BENEFITS[7]

Technology has advanced to such an extent that there are now a number of alternative ways of entering or inputting data and information into an military crew stations. However, like most technology insertion activities, if not integrated properly then significant problems can occur in service use. To ease the operator burden, the implementation of these alternative technologies requires a human centered approach to integration. In design, operator requirements should retain a major influence.

As operator-in-the-loop systems become more complex, and the pace of conflict increases, one expected benefit of implementing alternative technologies may be they help in these potential "overload" conditions by offering redundant or supplemental control/display alternatives. Another expected benefit is the potential for a reduction in training requirements, time and subsequently costs. Each of these is briefly discussed in the sections below; however, identifying potential areas of benefits offered by technologies in the earliest phases of research (i.e., without quantitative laboratory or field research performance data) becomes very speculative.

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[6] Retrieved May 10, 2001 from Soltan, P., Lasher, M., Dahlke, W., Acantilado, N., McDonald, M. (1996). *Lasar projected 3-D volumetric displays*. San Diego, CA: NCCOSC RDT&E Division, Technical Information Division. (http://www.nosc.mil/sti/publications/reprints/3dvolumetricdisplay/reprints/soltan/volu.html)

[7] Much of the content of this section is extracted from a paper by Leger, A. (1998). Synthesis- and expected benefits analysis. In *Alternative control technologies: Human factors issues* (RTO-EN-3). Neuilly-Sur-Seine Cedex, France: North Atlantic Treaty Organization, Research and Technology Organization. This paper presents a lengthy synthesis and analysis of advanced technology capabilities, limitations, and benefits for military applications.

3.3.1 Redundancy and Alternative Solutions

Alternative technologies may be used, in many cases, as supplements and substitutes within an existing interface. Supplements are used when, for example, a new task is being introduced, or it may be a substitute for another control.

The most simple approach, redundancy to already existing manual control, would create a total or partial equivalence between the new control and the traditional manual control modality. The advantage would be to offer to the warfighter an alternative control option, especially when short-term memory problems are encountered with HOTAS switches.

This kind of consideration shows that it is of interest to assess benefits and weakness of the potential technological candidates in regard of human factors and system engineering technology. Tables 3 and 4 show an example, far to be exhaustive, of such assessment for the reviewed technologies, relative to current state of the art characteristics.

Table 3 considers five system engineering criteria: (1) response rapidity, as the time between an input to the control system and an output to the system (fast = 20 ms or less), (2) reliability (makes a consistent response to an operator input), (3) ease to provide a feedback, (4) tolerance to dynamic environments (e.g., shock/vibration; g-forces), and (5) ease to set up the system. Speech/audio-based devices and eye-/head-trackers currently present some obvious limitations in speed and system setup respectively. However, these alternative technologies do offer acceptable to good benefits across the remaining categories and are currently implemented in many military and commercial systems. Continued advancement in the area of tactile feedback shows great promise as witnessed by the TSAS program; and current commercial/medical applications of biopotential-based technologies will surely advance R&D for its use within the military environment. However, gesture- and biopotential-based technologies have serious limitations and uncertainties in most areas.

Table 3. Compliance of alternative technology with various system and environmental criteria (adapted from Leger, 1998)

	Fast	Reliability	Easy Feedback	Dynamics Tolerance	Easy Setup
Speech/Audio	-	±	±	±	+
Head-based	+	+	+	+	+
Eye-based	±	±	±	+	-
Gesture/Tactile	±	-	-	±	-
Biopotential	±?	±	-	±	-

Legend +: good, ±: acceptable, -: nonacceptable, ?: questionable

Table 4 examines the same technologies against some operator's usage criteria: (1) low attention on control, (2) high confidence in system operation, (3) intuitive interaction/control, (4) easy error correction/recovery, and (5) delay between the control/display intent and the input. Head- and speech/audio-based technologies appear to comply quite well to all these criteria, with a limitation to the speed of input associated with current generation ASR technologies. Eye-based technologies exhibit some uncertainties and weaknesses, especially in the area of user confidence in the system and the inability to correct or recover easily from errors. Again, gesture and biopotential-based technologies are the least compliant and suffer from a lack of maturity for the operational environment.

Table 4. Compliance of alternative technology with various operator use criteria (adapted from Leger, 1998)

	Low attention on control	High confidence	Intuitive	Easy error correction	Delay intent/input
Speech/Audio	±	±	±	±	-
Head-based	+	+	+	+	±
Eye-based	±	?	+	±?	+
Gesture/Tactile	±	±	±	-?	±?
Biopotential	-	-	±	-?	+?

Legend +: good, ±: acceptable, -: nonacceptable, ?: questionable

3.3.2 Training Considerations

A strong point to the introduction of alternative technologies is that they are supposed to be more intuitive than conventional controls. This should imply that training needs would be reduced, yielding significant benefits as training is inevitably associated with costs. Things, however, may not be that simple, as technology does not perfectly mediate the natural modalities used by the operator. On the other hand, in regard of memory management, using alternative control could help the pilot to rapidly reach a given level of global proficiency on the aircraft system.

The relationship between characteristics of technology and training issues is not very well understood. Some technologies, in their current status, explicitly call for some kind of training, as EMG and EEG. Gesture is also highly susceptible to require substantial training if specific communication capabilities are used.

This domain not clearly defined and little work has been identified in the literature that addresses the impact of alternative controls on training. It could be expected that redundancy and alternative solutions could globally facilitate training on complex systems, as the operator's limited resources could be better used. This kind of issue definitely deserves some attention, since demonstration of training process improvements may constitute a strong point for integration of these technologies in existing and future cockpits.

3.4 SURVEY RESULTS

An internet and literature database search was conducted and key SMEs/Sources were identified and contacted to (1) capture commercial, academic, and laboratory research and development (R&D) efforts not yet published in the open literature and (2) support development of the Alternative Control and Display Technology Matrix found in Appendix B. This section describes the method followed and the results of those endeavors.

3.4.1 Identification Method

Analysis of government, commercial and web database search results was the primary method by which SMEs/Sources were identified. In addition, when articles and citations were thought to be of use, the papers were acquired and attempts were made to locate either the personal or corporate authors to obtain further information. A web search was also conducted to identify current technology vendors, as well as R&D projects by various corporations, laboratories or academic research institutes. Symposium announcements and agendas were identified as valuable sources of SME information. Finally, Dr. Joe McDaniel (AFRL/HECI; HSIAC COTR) initiated an email request to members of the *Controls and Displays/Voice Interactive Systems Human Factors*

Engineering (HFE) SubTAG (Technical Area Group) and requested input regarding ongoing alternative control and display R&D efforts.

3.4.2 Results

Human Systems IAC was able to identify approximately 45 SMEs or technology sources in the specific control/display technology areas of interest. Due to time and budgetary constraints, attempts were made to contact only 24. Of these, HSIAC had received either phone or email feedback from nine by the time this report was completed. The following summarizes the results of those contacts:

1. Contact Information: Dr. Glenn Osga, PhD, CPE
Code D441
SPAWARSYSCEN San Diego
Phone: (619) 553-3644
mailto:osga@spawar.navy.mil

Dr. Osga's work deals in the environment of land attack mission areas and multimodal workstation design. There are currently two versions of the multimodel watchstation and CDs available for distribution. We received two papers from Dr. Osga, one on touch selection with further points of contact and a second on studies of the multimodal watchstation for Navy ship consoles. The touch selection work deals with a proximity algorithm that cuts tracking time in half and was tested on a 2D display.

2. Contact Information: Capt. Richard Friedman
AFRL/HECP
2255 H Street
WPAFB, OH 45433
Phone: (317) 278-0116
mailto:rfriedma@iupui.edu

Capt. Friedman has been working on a bioelectrical 2-axis alternative controller for patients having high-level spinal cord injuries whose limbs have limited function. He noted that this technology could be used by warfighters as an alternative control method under high-workload conditions (i.e., when their limbs were occupied with tasks). Both types of people require additional (alternate) means of controlling their environment and commanding external instruments. He recently authored a paper for The Journal of Spinal Cord Medicine entitled *"Preliminary Electrophysiological Characterization of Functionally Vestigial Muscles of the Head: Potential for Command Signaling."*

3. Contact Information: Gloria Calhoun
AFRL/HECV
2255 H Street
WPAFB, OH 45433
Phone: (937) 255-3856
mailto:gloria.calhoun@wpafb.af.mil

Ms. Calhoun is working on an SBIR project that deals with an integrated, hands-free control suite for wearable computers. The advent of wearable computers marks a potential revolution in human-machine interaction and necessitates an expansion of control and display capability. Hands-free, head-up controllers are required to fully exploit the advantages of wearable computers when the

operator is also performing manual tasks in the work setting. This SBIR demonstration shows a promising hands-free interface for wearable computers with head-mounted displays: the Voice/Head Input Controller (VHIC). Voice (optimized for high noise) is used for command and text entry and head movement (via a head-mounted inertial cube) is used for pointing/spatial inputs. The VHIC is designed to work with any PC platform using Windows application software, making it useful for most any task. Such a hands-free controller coupled with wearable computers has wide application: maintenance, inventory, inspection, training, field medicine, law enforcement, infantry, disabled assistance, surveying, and space operations.

4. Contact Information: Dr. John Reising
HFRL/HEC
Human Effectiveness Directorate
WPAFB, OH 45433
Phone: (937) 255-8769
mailto:john.reising@wpafb.af.mil

Dr. Reising was contacted on his work with touch selection technologies. He has worked with touch displays and tested the proximity algorithm that Dr. Osga developed in a 3D presentation type format. This technology can be used in aircraft, ships, tanks or ground based control displays. He has had his studies patented for use by the Navy and has models and demos available for the touch selection display screens. They have been developed through algorithms made from off-the-shelf technologies.

5. Contact Information: Dr. Grant McMillan
HFRL/HEC
Human Effectiveness Directorate
2255 H Street
WPAFB, OH 45433
Phone: (937) 255-8766
mailto:grant.mcmillan@wpafb.af.mil

Dr. McMillan has been working on a Phase II SBIR with Sytronics that is integrating head tracking and speech recognition for hands-free interaction with a wearable computer. The head tracker is used for cursor control on the head-mounted display of a wearable computer. Speech recognition is used to issue discrete commands and to navigate through menus. Target users include maintenance technicians, inventory control personnel, medical personnel operating in field environments, and anyone else who need hands-free access to critical information sources.

6. Contact Information: CAPT Angus Rupert, MC USN, M.D., Ph.D.
U.S. Naval Aeromedical Research Laboratory
Pensacola, FL 32508-1046
Phone: (850) 452-4496

HSIAC was able to contact an associate of CAPT Rupert, who works for the Naval Aeromedical Research Laboratory to give us information on the TSAS. The TSAS is being developed currently and will be used for V-22 Osprey pilots to help detect the movements of the aircraft by sensors felt on their body through the vest. Additional information can be found at <http://www.namrl.navy.mil/accel/TSAS/index.htm>.

7. Contact Information: Kenneth Wauchope
Navy Center for Applied Research in Artificial Intelligence (NCARAI)
Naval Research Laboratory, Code 5512
Washington, DC 20375-5337
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mailto:wauchope@aic.nrl.navy.mil.

Mr. Wauchope has been working on multimodal interface concept demonstrations for the Navy by adding speech or spoken natural language I/O to existing military applications, integrating as much as possible with the existing graphical user interface. These applications have included KOALAS (NAVAIR command & control simulation), VIEWER (NRL virtual reality stealth viewer), LACE (Air Force combat simulation with cartographic database), QuickSet (Oregon Graduate Institute multimodal interface), Battlespace Visualization Tool (Marine Corps situational awareness software), and GIDB (NRL Stennis's geographic information database). The BVT speech interface for the Marines sounds like it might be a good match for the ARL/HRED crew station operations task. Their objective was to allow a soldier to operate GUI-based software on a portable or wearable computer by voice only, either eyes-engaged or eyes-busy. The same interface has been installed on desktop machines in a command center during recent Marine exercises. At any time the user is free to use either GUI or speech to navigate the system and fill in message templates. There is no natural language processing involved, just a highly extensible integration of speech commands with Java Swing graphics using the Java Speech API. The multimodal research that Mr. Wauchope has been impressed with lately is QuickSet and its agent-based architecture and unification-based approach to multimodal integration. One possible research direction they are moving towards is "perceptual user interfaces" which detect user behaviors that are not intentional inputs or commands to the system.

8. Contact Information: Linda Sibert
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Ms. Sibert was involved with eye tracking work and compiled a paper titled, *Evaluation of Eye Gaze Interaction*. The paper describes her work on testing eye behavior and eye gaze interaction algorithm development. Another point of interest is work that is being done by her colleague, Jim Templeman. The Immersive Simulation Lab at Naval Research Laboratory is developing a new virtual locomotion technique named "Gaiter" that allows a person to move in a natural way through a virtual environment (VE). Their approach adopts walking in place as the basis for virtual locomotion. Walking and running in place are expressive gestures that exhibit many of the attributes of natural human gate. In-place stepping allows people to turn and change posture in a natural manner. Gaiter is part of a personnel simulator to train Marines in close quarters combat that is being developed by the VIRTE program at the Office of Naval Research.

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Mr. Williamson is involved with a speech recognition technologies that are at a very high level maturity. One is called Tabtalk and will be used for the command and control center of a C^2 battleship. It is set up for a data entry operator to build up the linguistics in 30-40% of the time. The fielding of this project will hopefully be in the next year. This is based from off the shelf technologies through Nuance Communications, which tries to simulate natural speech language capabilities and is speaker independent, in a noisy environment. They are also working on HES, which is speech technology over FM radios and is for a flight line application. Another technology mentioned is the Strike Helmet 21, which is for the F-15 and will be used for these airborne applications. It is a combination of speech recognition with a helmet mounted display. It is foreseen to be at a fielding maturity level in four to five years. There has also been recent efforts put forth to work with the test pilot school to combine ITT Command Voice and a boxware system for the F-16 called VSTA.

The Alternative Control and Display Technology Matrix found in Appendix B was used to compile and summarize the results of the SME/Source Survey effort. Within this matrix you will find technology descriptions, additional point of contact and/or web source information, estimated maturity level, and perceived technology benefits to the warfighter as indicated within the product description.

4. CONCLUSIONS[8]

Future Army crew stations will inevitably have more complex technology to cope with more demanding operational scenarios. There will need to be a corresponding advance in the way that the warfighter interfaces with systems to enable efficient control and information transfer. The benefits of alternative control/display technologies presumably lie in a more natural interface with the platform and the potential for improvements in the speed of operation while reducing training overhead.

Optimizing crew station design by introduction of alternative controls and displays would mean considering cost issues at two levels:

1. For the user, the aim of alternative technology should be to minimize the cost of control by making the best use of limited human resources and increasing the global effectiveness of human-machine coupling;
2. For the Defense community, the smart integration of these new control technologies should result in training cost reduction, increased operational effectiveness and, eventually, crew station simplification.

Of the more mature alternative technologies, ASR and head-based are both in operational use and experimental use–depending upon the level of sophistication of the technology–and are both technically mature enough now for full operational use, with research on the next generation, higher capability, systems in progress.

Eye-based control is laboratory mature and is used for assessing eye movement in simulators. With further development it has the potential to integrate effectively in the operational environment with head- and voice-based control. It may enable a range of potentially useful explicit and implicit control functions. The technology is not yet mature enough for complete integration into the operational environment, but the necessary advances can probably be made in the near (two to four yrs) to mid term (four to seven yrs). Gesture and biopotential are probably the least mature, but provide potential for future generation systems (2020).

Virtual retinal displays (VRD), tactile vests, and volumetric displays were also discussed. VRDs and tactile vests are somewhat mature technologies being implemented in a limited fashion or being demonstrated operationally within the DoD. Volumetric displays appear useful in presenting large volumes of 3D data that may be useful in command and control environments but appears to have limitations that will prevent their effective near-term use in Army crew stations.

The most evident need is to be able to calibrate the appropriate system to match the possible mixture of voice, eye, hand gesture and cortical response characteristics of the user to optimize accuracy and reliability in multisensory systems.

Quite likely, the major difficulty in integrating alternative controls and displays more extensively into crew station design will arise from the unique adaptive ability of the human being. Among individuals, various strategies using various modalities will be developed to successfully perform a similar task. From an engineering point of view, the challenge, therefore, will be to determine among the various technologies and combination possibilities what to do, and why and how to implement it at the lowest human and economical cost.

It appears a noticeable amount of work remains to be done by researchers and engineers both in the human factors and engineering domains to prove and provide the benefits that might be gained by integrating alternative technologies into future crew station environments. Integration of these

[8] Primarily drawn from Rood, G. M. (1998). Operational rationale and related issues for alternative control technologies. In *Alternative control technologies: Human factors issues* (RTO-EN-3). Neuilly-Sur-Seine Cedex, France: North Atlantic Treaty Organization, Research and Technology Organization.

technologies requires more than putting boxes side by side and physical connection to the Army platform. Achieving a meaningful and smart implementation of these technologies will require a synergistic effort involving research labs, system manufacturers and equipment makers.

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7. APPENDIX A: LITERATURE SEARCH STRATEGY

LITERATURE REVIEW SUPPORT TO THE HUMAN RESEARCH AND ENGINEERING DIRECTORATE U.S. ARMY RESEARCH LABORATORY

STATUS UPDATE OF ALTERNATIVE CONTROL AND DISPLAY TECHNOLOGIES

BACKGROUND

This Human Systems IAC (HSIAC) Subscription Account Work Plan provides support to the Human Research and Engineering Directorate of the U.S. Army Research Laboratory (ARL) and addresses Human Factors Engineering research questions associated with nontraditional or alternative information processing controls and displays. The integration of advanced technologies into Army systems has the potential for making soldier operation of these systems more efficient and effective, as well as providing the soldier with greater situational awareness at lower levels of cognitive workload. Some of these technologies, known as alternative control and display technologies, involve the aiding or augmentation of information to and from the soldier by nontraditional modalities, so that the soldier can respond more quickly to the demands of the battlefield within the crew station (ground and air) environment. ARL performs research exploring the integration of advanced/alternative information technologies within Army crew systems. However, ARL needs to be appraised of current and/or developmental alternative control and display technologies and identify when they might be available.

TASKING

HSIAC will perform a literature search and contact subject matter experts to determine the status of advanced/alternative controls and displays. HSIAC will identify these technologies and assess their relevance to the improvement of soldier performance. Potential alternative display technologies may include, but are not limited to, helmet mounted displays (HMDs), tactile vests, virtual retinal displays, and spatial auditory displays. Potential alternative control technologies may include, but are not limited to, voice-based (speech recognition), gaze-based, gesture-based, head-based, and biopotential-based controls.

SUGGESTED SEARCH TERMS/STRATEGY

control(s)/control(s) coding	and	ground vehicles
control system(s)		aircraft/rotorcraft
alternative/advanced		human factors (engineering)
voice-based (speech recognition)		avionics
gaze-based (head/eye coupled)		human performance
gesture-based		flight/navigation instrumentation
head-based		information/information technology
biopotential-based		crew stations/systems
physiology(ical)-based		
sound activated		
comparison/selection among		
display(s)/display(s) coding		
display system(s)		
alternative/advanced		
helmet mounted (HMD)		
tactile display/tactile vest		
haptic display(s)		
retinal		
spatial auditory (3D audio)		
projected		
stereoscopic (3D)		
Comparison/selection among		

8. APPENDIX B: ALTERNATIVE CONTROL AND DISPLAY TECHNOLOGY MATRIX

Technology Type	Product	Source/ Subject Matter Experts	Maturity Level[1]	Environment/ Application	Description
		Display Technologies			
Eye-and-Head Based					
	3-D video and audio display	I-O Display Systems, LLC 1338 N. Market Blvd. Sacramento, CA 95834 Phone: (916) 928-9639 Fax: (916) 928-9539	Phase II	Designed for gaming, but could be adapted	8-oz. head mounted system with 3-D audio and 3-D video displays. Portable, light weight, effective.
	Olympus Eye-Trek	http://www.olympusamerica.com/	Phase I-II	Currently, gaming/ video environment	3-D visual display system with stereo surround sound.
	Technique to incorporate a second control modality for closed loop error correction	Applied Science Laboratories 175 Middlesex Turnpike Bedford, MA 01730	Phase 0	Aircraft cockpits	A technique that allows users to switch from point-of-gaze control to a low gain head position control when near the target.
		Dr. Grant McMillan Crew Systems Interface Div., HFRL/HEC, Human Effectiveness Directorate 2255 H Street Bldg. 248 WPAFB, OH 45433 Phone: (937) 255-8766 mailto:grant.mcmillan@wpafb.af.mil			Phase II SBIR with Sytronics that is integrating head tracking and speech recognition for hands-free interaction with a wearable computer. The head tracker is used for cursor control on the head-mounted display of the wearable computer. Speech recognition is used to issue discrete commands, to navigate through menus, etc. Target applications include maintenance technicians who need hands-free access to technical manuals, inventory control personnel, medical personnel operating in field environments, etc.
	Head control unit	VA Medical Center Office of Technology Transfer	Phase I-II	Vehicle cockpit control	The VA R&D developed Ultrasonic Head Control Unit as an add-on

Technology Type	Product	Source/ Subject Matter Experts	Maturity Level[1]	Environment/ Application	Description
		3801 Miranda Avenue, MS-153 Palo Alto, CA 94304 Tel: (6500 493-5000 Fax: (650) 493-4919 http://guide.stanford.edu/Projects/ultra.html			interface for wheelchairs that provides a non-contact alternative to chin control for quadriplegic population.
	Head Tracked Vision System	Wayne Diamond Kaiser Electronics (408)-432-3000; X1148			
Tactile/Gesture					
	Touch selection display screens	John Reising Tech-Advisor Crew Systems Interface Div., HFRL/HEC, Human Effectiveness Directorate WPAFB Dayton, OH 45433 Phone: (937) 255-8769	Phase III	Designed for Navy use, aircraft, ships, tanks or ground based control displays.	Touch displays, touch selection software, models and demos and has tested the proximity algorithm that Dr. Osga developed in a 3D presentation type format. Studies patented for use by the Navy and has models and demos available for the touch selection display screens. They have been developed through algorithms made from off the shelf technologies.
	Tactile Situation Awareness System (TSAS)	CAPT Angus Rupert USN, Naval Aeromedical Research Laboratory Pensacola, FL 32508-1046 Phone: (850) 452-4496	Phase II	Airborne crew station	Tactile vest
	Gesture based input system	Thomas Moran Palo Alto, CA Patrick Chiu Menlo Park, CA Assignee; Xerox Corporation Stamford, CT	Phase II		A graphical editing system is used that allows a user to draw on a number of commonly used gestures called primitive command gestures together in essentially one stroke and the primitive gestures are chosen to represent gestural syntax, analogous to a textual command syntax.
	Voice-Output Reading System with Gesture-Based Navigation	James T. Sears Boulder, CO David A. Goldberg Boulder, CO	Phase I-II	Learning to read, Data input and image capture for home and business use	An optical-input print reading device with voice output for people with impaired or no vision in which the user provides input to the system from hand gestures. Feedback is

Technology Type	Product	Source/ Subject Matter Experts	Maturity Level	Environment/ Application	Description
		Assignee; Ascent Technology, INC Boulder, Co			provided to the user through audible and tactile means.
	Video Hand Image Three-Dimensional Computer Interface	Senthil Kumar Aberdeen, NJ Jakub Segen Fair Haven, NJ Assignee; Lucent Technologies, Inc. Murray Hill, NJ	Phase II		Video gesture-based three-dimensional computer interface that uses images of hand gestures to control a computer and that tracks motion of the user's hand in a three-dimensional coordinate system with five degrees of freedom.
Speech/Auditory					
		Carol A. Simpson Psycho-Linguistic Research Associates 485 Summit Springs Road. Woodside, CA 94062 Nancy Bucher NASA Ames Research Center MS 243-4 Moffett Field, CA 94035-1000 (415) 604-5161 Current vendors; ITT Defense Communications Marconi Electronics Smiths Industries Votan		Advanced combat helicopters	Research completed describes current vendors technologies using speech recognition and compares it to newer technologies in the area to assess the benefits of the Army's switching to a newer technology.
	Dragon	Phone (610)328-5962 Fax 603 994-5972 http://www.astvtech.com/	Phase II	Office environment	Current use is in office environment. Adaptation to increase robustness is possible
	ITT Industries Command Voice	Sheri McCorkle (219)-451-6230 mailto:Sheri.McCorkle@itt.com	Phase III	Air Force (F-16, OV-10), Army (C2 & combat platforms), Navy/Corps (Tactical Ops Center, ATC), FAA (ATC)	ITT's Command Voice! Family of Tactical Voice Recognition Systems provides state-of-the-art speech processing technology in real-time. High performance voice recognition and control capability are ideal for

Technology Type	Product	Source/ Subject Matter Experts	Maturity Level[I]	Environment/ Application	Description
					tactical application in high noise and high stress environments.
	Tabtalk HES	Dave Williamson HECA 2255 H Street Bldg. 248 WPAFB, OH 45433 Phone: (937) 255-7593 mailto:david.williamson@wpafb.af.mil	Phase III for Tabtalk	C^2 battleship as well as, flightline application for the HES and the F-15 flight eagle for the Strike-Helmet 21. Also, the F-16 for the last technology mentioned, VSTA.	Tabtalk will be used for the command and control center of a C2 battleship. It is set up for a data entry operator to build up the linguistics in 30-40% of the time. This is based from off the shelf technologies through Nuance communications, which tries to simulate natural speech language capabilities and is speaker independent, in a noisy environment. They are also working on HES, which is speech technology over FM radios and is for a flight line application. Another technology mentioned is the Strike Helmet 21..It is a combination of speech recognition with a helmet mounted display. There has been recent efforts put forth to work with the test pilot school to combine ITT Command Voice and a boxware system for the F-16, called VSTA.
Biopotential	Ames Autogenic-Feedback Training System	NASA Ames Research Center Commercial Technology Office Mail Stop 202A-3 Moffett Field, CA 94035-1000 Phone: (415) 604-5761 Fax: (415) 604-1592 http://ctoserver.arc.nasa.gov:80/TechOpps/afte.html	Phase I-II	Cockpit displays, motion displays, etc.	A six-hour training program which is a highly efficient and effective method of enabling people to control voluntarily several of their own physiological responses to a variety of environmental stressors.
	Neuro-electric device control	Chuck Jorgensen NASA Ames Research Center	Phase I-II	Aircraft	Control for the 757 plane involving a specific type of sensor
	Bioelectrical 2-axis controller	Capt. Richard Friedman Phone: (317) 278-0116 mailto:rfriedma@iupui.edu	Phase I-II		

Technology Type	Product	Source/ Subject Matter Experts	Maturity Level	Environment/ Application	Description
Other					
	Multi-Modal Watchstation	Dr. Glenn Osga, PhD, CPE Navy Code D441 SPAWARSYSCEN San Diego Phone: (619) 553-3644 mailto:osga@spawar.navy.mil	Between phase I and II	Air defense warfare and now moving into land attack mission areas	There are currently two versions of the multi-model watchstation and CDs for distribution. The touch selection work deals with a proximity algorithm that cuts tracking time in half and was tested on a 2D display.
	AMMWS: Multimodal HCI Development	Kenneth Wauchope Navy Center for Applied Research in Artificial Intelligence (NCARAI) Naval Research Laboratory, Code 5512 Washington, DC 20375-5337 wauchope@aic.nrl.navy.mil (202) 767-9004	Phase I	C^2	Multimodal HCI Development for the Advanced Multimodal C^2 Watchstation, Thrust 2 of the SC-21 Science and Technology Manning Affordability Program. The objective is to use state-of-the-art interface technology to reduce manning requirements at the combat command and control center aboard the Navy's next generation warships.
	3-D Virtual Acoustic display	Elizabeth M. Wenzel NASA Ames Research Center MS 262-2 Moffett Field, CA 94035-1000 (415) 604-6290	Phase I	Currently, human machine interfaces, but moving towards a larger multisensory environment	A means for accurately transferring information to a human operator using the auditory modality; it combines directional and semantic characteristics for natural representations of dynamic objects in a simulated environment.
	3-D Virtual display	Kopin Corporation 695 Myles Standish Blvd. Taunton, MA 02780 Tel 508-824-6696 Fax 508-824-6958 http://www.kopin.com/index.html	Phase II-III	Video displays, wearable computers, etc.	Active Matrix Liquid Crystal Displays (AMLCD) smaller than 1 inch.
	Gaiter	Linda Sibert Code 5513 Naval Research Laboratory 4555 Overlook Avenue, SW Washington, DC 20375-5337 Phone: (202) 767-0824 Fax: (202) 404-4080 e-mail: sibert@itd.nrl.navy.mil	Phase I-II	Marine fire teams fighting in urban combat, but could be used in other environments in the future.	The Immersive Simulation Lab at Naval Research Laboratory is developing a new virtual locomotion technique named Gaiter that allows a person to move in a natural way through a virtual environment (VE). Gaiter is part of a personnel simulator to train Marines in close

Technology Type	Product	Source/ Subject Matter Experts	Maturity Level[1]	Environment/ Application	Description
					quarters combat that is being developed by the VIRTE program at ONR.
	3-D Display	Vantage Lighting, Inc 175 Paul Drive San Rafael California 94903-2041 USA phone: (800-445-2677) fax: 1-415-507-0502	Phase II	Air Traffic Control/Command and Control; data display	3-D display without glasses. Ideal for indoor use (e.g., ATC).
	3-D Display	Holoverse P.O. Box 289 Yarmouth Port, MA 02675 Phone: 001 508 394 9221 info@holoverse.com Other researchers: Stanford University Texas Instruments U.S. Navy	Phase II	Air Traffic Control/Command and Control; data display	True 3-D image with "volume"

1. maturity level as represented by the four phases of the Defense Systems Acquisition Management Process and approximate number of years from operational deployment: Phase 0 > Concept Exploration (≥ 12 yrs); Phase I > Program Definition & Risk Reduction (4-7 yrs); Phase II > Engineering & Manufacturing Development (2-4 yrs.); Phase III > Production, Fielding/Deployment, & Operational Support (0-2 yrs).

9. APPENDIX C: NONCOPYRIGHTED SEARCH RESULTS

ORDERING DOCUMENTS

9.1 DEFENSE TECHNICAL INFORMATION CENTER (DTIC)

DTIC is the central repository for documents resulting from research supported by the Department of Defense (DoD). DTIC maintains several databases, including Technical Report (TR) database, Technical Effort and Management System (TEAMS) Database, and Independent Research and Development (IR&D) Databases.

Documents from the DTIC TR database (including documents from the DTIC CD-ROM) are identified by an accession number that begins with "AD," such as AD-A123 456. Most of these documents are available through DTIC. Some of the documents may not be available through DTIC; however, the citations for these documents contain the necessary document acquisition information.

To order DTIC documents, organizations must have a deposit account established with the National Technical Information Service (NTIS, see below), against which document ordering fees will be charged. Call DTIC if you do not have information on establishing a deposit account with NTIS. When ordering documents from DTIC, please cite your DTIC User Code.

Defense Technical Information Center
Reference and Retrieval Division (DTIC-BR)
8725 John J. Kingman Road, Suite 0944
Ft. Belvoir, VA 22060-6218
Telephone: (703) 767-8274 / DSN 427-8274
1-800-CAL-DTIC (225-3842), menu selection 1
FAX: (703) 767-9070 / DSN 427-9070
mailto:msorders@dtic.mil
http://www.dtic.dla.mil/dtic/docorder.html

9.2 NATIONAL TECHNICAL INFORMATION SERVICE (NTIS)

NTIS is a major source for US and foreign government-sponsored research documentation. Orders for NTIS documents can be charged to an NTIS Deposit Account, American Express, Visa, or MasterCard. For additional information on establishing a deposit account, you may contact NTIS directly at (703) 487-4064. NTIS document orders may also be placed using the following information:

Telephone Orders: 8:30-5:50 EST (703) 487-4650
Mail Orders: NTIS, Springfield VA 22161
FAX Orders: (703) 321-8547
For Assistance: (703) 487-4679
mailto:orders@ntis.fedworld.gov.
http://www.fedworld.gov/ntis/ntishome.html

9.3 HUMAN SYSTEMS INFORMATION ANALYSIS CENTER (HSIAC)

We recommend that you discuss potential document orders with your in-house or local technical information specialist. He or she will know the most appropriate method to place orders for documents identified in this report. If questions do arise, please feel free to contact the Human Systems Information Analysis Center (HSIAC) at the address below.

AFRL/HEC/HSIAC
2261 Monahan Way, Bldg. 196
Wright-Patterson AFB, OH 45433-7022
Phone: (937) 255-4842
FAX: (937) 255-4823
mailto:hsiac@wpafb.af.mil
http://iac.dtic.mil/hsiac

AN (1) AD-B176 165/XAG
CA (5) MIDWEST SYSTEMS RESEARCH INC DAYTON OH
TI (6) Pilot Factors Research for Crew Systems Development.
DN (9) Final rept. 1 Mar 89-1 Mar 93
AU (10) Andes, William S.
Barry, Timothy
Hartsock, David
Kovacs, John A.
Lovering, Peter B.
RD (11) Sep 1993
PG (12) 80 Pages
RS (14) MSR-FR-93-12600-01
RN (18) WL*-TR-93-3079
XC-WL/WP
RC (20) Unclassified report
AL (22) Distribution authorized to U.S. Gov't. agencies and their contractors; Critical Technology; Sep 93. Other requests shall be referred to WL/FIPT, Wright-Patterson AFB, OH 45433-7562. This document contains export-controlled technical data.
DE (23) *PILOTS, *FLIGHT CREWS, *HUMAN FACTORS ENGINEERING, *FLIGHT SIMULATION AIR FORCE, AIRCRAFT, ATTITUDE INDICATORS, AUTOMATION, COCKPITS, CONTRACTS, CONTROL, CREWS, DATA LINKS, DOCUMENTS, DYNAMICS, FLIGHT TESTING, HEAD(ANATOMY), IMPACT, INDICATORS, INTERFACES, LABORATORIES, NAVIGATION, OHIO, OPERATION, PHOTOMETERS, RECOGNITION, RECOVERY, SKY, STATIONS, SWITCHES, TACTICAL AIRCRAFT, TRANSPORT AIRCRAFT, WORKLOAD, COMPUTER ARCHITECTURE
ID (25) EXPORT CONTROL, PE62201F, WUWL24030498
AB (27) The contents of this final report are provided as a summary of documented cockpit design efforts performed by Midwest System Research, Inc., between March 1989 and March 1993, for the United States Air Force at the Wright Laboratory., Joint Cockpit Office, Wright Patterson Air Force Base, Ohio. The work was performed under contract F3361588-C-3612, Pilot Factors Research for Crew Systems Development (PIFAX). This report summarizes all work accomplished on the contract over a 52-month period. More task specific, detailed information is contained in final reports and other documents for each task. Summary information is provided pertaining to work efforts in the following areas: MAGIC (Micro-Controller Enhanced Tri-Sensor Photometer, Super Switch, Font Studies, Unusual Attitude Recovery Studies, 3-D Cursor Studies, Head Down Display/Standardized Primary Flight Display, Standardized Military HUD, Voice Recognition, Pathway-In-The-Sky Navigation, and Bezel Attitude Indicator Studies) Generic Voice Interface Workstation Development; C-17 Crew Station Design/Evaluation Support; Tactical Aircraft Cockpit; Transport Aircraft Cockpit; FAA Mode-S Data Link; Adaptive Automation Support; SOF Simulation Architecture Definition; Control and Display Criteria; and Modeling the Dynamics of Mental Workload and Pilot Performance. Pilot, HUD, HDD, Pilot factors, ICASS, TACS, IMPACT, TRAC, MAGIC, C-17, SOF, Data link, Mode-S, Cockpit, Special Operations, SOA, Voice, Adaptive automation, Simulation architecture.

AN (1) AD-A150 044/XAG
CA (5) NAVAL AIR TEST CENTER PATUXENT RIVER MD
TI (6) Advanced Aircrew Display Symposium Proceedings (6th) Held at Patuxent River, Maryland on 15-16 May 1984.
RD (11) 16 May 1984
PG (12) 217 Pages
RC (20) Unclassified report
NO (21) Original contains color plates: All DTIC and NTIS reproductions will be in black and white.
DE (23) *Flight instruments, *Data displays, *Display systems, *Symposia Jet fighters, Integrated systems, Avionics, Cathode ray tube screens, Flight paths, Standardization, Great Britain, Flight crews, Airborne, Colors, Stations, Man machine systems, Performance(Human), Human factors engineering
ID (25) *Color display systems, F-15 aircraft, Crew stations
AB (27) The recent proliferation of new color display applications can be

traced to two interrelated trends: 1) a growing interest in the potential advantages of a color information display for enhancing human performance in complex man-machine systems; and 2) the availability of a rapidly evolving display technology to support advanced color display concepts. Table of Contents: A Systematic Program for the Development and Evaluation of Airborne Color Display Systems by L. Silverstein, Airborne Electronic Color Displays - A Review of UK Activity Since 1981 by R. Caldow, Color CRT in the F-15 by J. Turner and H. H Waruszewski, Integration of Sensor and Display Subsystems by D. Bohrer and P. Jenkins, Modernizing Engine Displays by E. Schneider and E. Enevoldson, Colored Displays for Combat Aircraft by C. Maureau, Display Technology and the Role of Human Factors by S. Roscoe, J. Tatro, and E. Trujillo, Pictorial Format Program: Past, Present, and Future by G. Lizza, J. Reising, and L. Hitchcock, The Command Flight Path Display - All Weather, All Missions by G. Hoover, S. Shelley, V. Cronauer, and S. Filarsky, Sensor-Coupled Vision Systems by T. Stinnett, An Argument for Standardization in Modern Aircraft Crew Stations by V. Devino.

AN (1) AD-P002 845/XAG
CA (5) NAVAL AIR DEVELOPMENT CENTER WARMINSTER PA
TI (6) Avionics/Crew Station Integration
AU (10) Mulley,W. G.
RD (11) Oct 1983
PG (12) 9 Pages
RC (20) Unclassified report
NO (21) This article is from 'Advanced Concepts for Avionics/Weapon System Design, Development and Integration: Conference Proceedings of the Avionics Panel Symposium (45th) Held at Ottawa, Canada on 18-22 April 1983,' AD-A138 600, p9-1-9-9.
DE (23) *Avionics, *Display systems, *Man machine systems Cockpits, Naval aircraft, Integrated systems, Interfaces, Pilots, Flight control systems, Human factors engineering, Bus conductors, Multiplexing, Video signals, Digital systems, Modules(Electronics), Data management, Life cycle costs
DC (24) (U)
ID (25) Crew stations, AIDS(Advanced Integrated Display System), NATO furnished, Component Reports
IC (25) (U)
AB (27) The U.S. Navy has been encouraging advanced development concepts aimed at increasing the aircraft instrumentation performance for multi-platform application of 1990's weapons systems. The system integration (R&D) objectives are to produce a system architecture easily adaptable to many platforms; technology objectives are to determine the state of the art for displays, electronics, and controls; and the human factors objectives are to determine the proper human-machine interfaces so that the ultimate crew station will be capable of providing the pilot with the proper display and controls performance to satisfy the diverse requirements of fighter, attack, ASW, fixed-wing, rotary-wing, and V/STOL platforms in both a one-man crew of two-man crew matrix. All data/control interfaces among units of this crew station system and other platforms subsystems will be via digital data buses and video multiplex buses. No individual discrete signal, data, or control lines will be needed. This paper discusses the six interfaces necessary to ensure the optimum development of this crew station, the predicted platform mission improvements, and the requisite life-cycle cost considerations. This concept will serve as a basis for planning the integration of the necessary hardware and software features in current and future weapons systems.

AN (1) AD-A385 248/XAG
CA (5) CREW SYSTEM ERGONOMICS INFORMATION ANALYSIS CENTER WRIGHT-PATTERSON AFB OH
TI (6) Gateway: Volume 6, Number 5
DN (9) ;Reuben L. /Hann ;Grant /McMillan ;Steve /Harper
AU (10) McNeese, Michael D.

RD (11) Apr 1996
PG (12) 17 Pages
CT (15) SPO900-94-D-0001
RN (18) XD-DTIC
RC (20) Unclassified report
DE (23) *HUMAN FACTORS ENGINEERING, *PHYSIOLOGY, *ERGONOMICS
CONTROL, STATIONS, DYNAMICS, COGNITION, CREWS, MAN MACHINE SYSTEMS, TIMELINESS, PERIODICALS, BIOMEDICINE
DC (24) (U)
AB (27) This issue contains articles on the following subjects: 1.Cognitive Engineering: A Different Approach to Human-Machine Systems; 2.Brain-Actuated Control: Thinking Ahead to "Firefox"; 3.A Conversation with Grant McMillan; 4.National Air Intelligence Center: Human Factors Analysis of Crew Stations CSERIACts objective is to acquire, analyze, and disseminate timely information on crew system, ergonomics (CSE). The domain of CSE includes scientific and technical knowledge and data concerning human characteristics, abilities, limitations, physiological needs, performance, body dimensions, biomedical dynamics, strength and tolerances. It also encompasses engineering and design data concerning equipment intended to he used, operated, or controlled by crew members.

AN (1) AD-B176 165/XAG
CA (5) MIDWEST SYSTEMS RESEARCH INC DAYTON OH
TI (6) Pilot Factors Research for Crew Systems Development.
DN (9) Final rept. 1 Mar 89-1 Mar 93
AU (10) Andes, William S.
Barry, Timothy
Hartsock, David
Kovacs, John A.
Lovering, Peter B.
RD (11) Sep 1993
PG (12) 80 Pages
RS (14) MSR-FR-93-12600-01
RN (18) WL*-TR-93-3079
XC-WL/WP
RC (20) Unclassified report
AL (22) Distribution authorized to U.S. Gov't. agencies and their contractors; Critical Technology; Sep 93. Other requests shall be referred to WL/FIPT, Wright-Patterson AFB, OH 45433-7562. This document contains export-controlled technical data.
DE (23) *PILOTS, *FLIGHT CREWS, *HUMAN FACTORS ENGINEERING, *FLIGHT SIMULATION
AIR FORCE, AIRCRAFT, ATTITUDE INDICATORS, AUTOMATION, COCKPITS, CONTRACTS, CONTROL, CREWS, DATA LINKS, DOCUMENTS, DYNAMICS, FLIGHT TESTING, HEAD(ANATOMY), IMPACT, INDICATORS, INTERFACES, LABORATORIES, NAVIGATION, OHIO, OPERATION, PHOTOMETERS, RECOGNITION, RECOVERY, SKY, STATIONS, SWITCHES, TACTICAL AIRCRAFT, TRANSPORT AIRCRAFT, WORKLOAD, COMPUTER ARCHITECTURE
ID (25) EXPORT CONTROL, PE62201F, WUWL24030498
AB (27) The contents of this final report are provided as a summary of documented cockpit design efforts performed by Midwest System Research, Inc., between March 1989 and March 1993, for the United States Air Force at the Wright Laboratory., Joint Cockpit Office, Wright Patterson Air Force Base, Ohio. The work was performed under contract F3361588-C-3612, Pilot Factors Research for Crew Systems Development (PIFAX). This report summarizes all work accomplished on the contract over a 52-month period. More task specific, detailed information is contained in final reports and other documents for each task. Summary information is provided pertaining to work efforts in the following areas: MAGIC (Micro-Controller Enhanced Tri-Sensor Photometer, Super Switch, Font Studies, Unusual Attitude Recovery Studies, 3-D Cursor Studies, Head Down Display/Standardized Primary Flight Display, Standardized Military HUD, Voice Recognition, Pathway-In-The-Sky Navigation, and Bezel Attitude Indicator Studies) Generic Voice Interface Workstation Development; C-17 Crew Station Design/Evaluation Support; Tactical Aircraft Cockpit; Transport Aircraft Cockpit; FAA Mode-S Data Link; Adaptive Automation Support; SOF Simulation Architecture Definition;

Control and Display Criteria; and Modeling the Dynamics of Mental Workload and Pilot Performance. Pilot, HUD, HDD, Pilot factors, ICASS, TACS, IMPACT, TRAC, MAGIC, C-17, SOF, Data link, Mode-S, Cockpit, Special Operations, SOA, Voice, Adaptive automation, Simulation architecture.

AN (1) AD-A380 986/XAG
CA (5) NAVAL POSTGRADUATE SCHOOL MONTEREY CA
TI (6) Design of a Low Power Embedded Microprocessor for a Hands-Eyes-Ears-Free Personal Navigation and Communications System
DN (9) Master's thesis
AU (10) Haase, Peter H.
RD (11) Jun 2000
PG (12) 132 Pages
RN (18) XB-NPS
RC (20) Unclassified report
DE (23) *LOW POWER, *MICROPROCESSORS, *EMBEDDING
OFF THE SHELF EQUIPMENT, THESES, ENGINEERING, NAVIGATION, GLOBAL POSITIONING SYSTEM, RADIO RECEIVERS, WEAR, COMMERCIAL EQUIPMENT, LONG LIFE, COMPUTER APPLICATIONS, COMMUNICATION AND RADIO SYSTEMS, TRAVEL, VEHICLES, MICROCOMPUTERS, BATTERY COMPONENTS, TOUCH, MINICOMPUTERS, ELECTRIC BATTERIES, VESTS
ID (25) *PERSONAL NAVIGATION, *PERSONAL COMMUNICATIONS, PNCS(PERSONAL NAVIGATION AND COMMUNICATIONS SYSTEM)F
AB (27) This thesis details the engineering design of a personal, computer-based system. which is intended to support a hands-eyes-ears-free Personal Navigational and Communication System (PNCS). This computer-based system is designed to be used with COTS devices, such as, (1) a GPS receiver, (2) a laptop or desktop computer, (3) a rechargeable, long-life battery pack, and (4) a wearable tactile communications vest. The vest is currently under development by the Naval Aerospace Medical Research Lab (NAMRL) and together with this computer-based system can provide a complete hands-free personal navigational and communication system. The intent of the navigation system is to satisfy both commercial and milita uses for land-based edestrian and vehicular travel.

AN (1) AD-B176 165/XAG
CA (5) MIDWEST SYSTEMS RESEARCH INC DAYTON OH
TI (6) Pilot Factors Research for Crew Systems Development.
DN (9) Final rept. 1 Mar 89-1 Mar 93
AU (10) Andes, William S.
Barry, Timothy
Hartsock, David
Kovacs, John A.
Lovering, Peter B.
RD (11) Sep 1993
PG (12) 80 Pages
RS (14) MSR-FR-93-12600-01
PJ (16) 2403
TN (17) 04
RN (18) WL*-TR-93-3079
XC-WL/WP
RC (20) Unclassified report
AL (22) Distribution authorized to U.S. Gov't. agencies and their contractors; Critical Technology; Sep 93. Other requests shall be referred to WL/FIPT, Wright-Patterson AFB, OH 45433-7562. This document contains export-controlled technical data.
DE (23) *PILOTS, *FLIGHT CREWS, *HUMAN FACTORS ENGINEERING, *FLIGHT SIMULATION
AIR FORCE, AIRCRAFT, ATTITUDE INDICATORS, AUTOMATION, COCKPITS, CONTRACTS, CONTROL, CREWS, DATA LINKS, DOCUMENTS, DYNAMICS, FLIGHT TESTING, HEAD(ANATOMY), IMPACT, INDICATORS, INTERFACES, LABORATORIES, NAVIGATION, OHIO, OPERATION, PHOTOMETERS, RECOGNITION, RECOVERY, SKY, STATIONS, SWITCHES, TACTICAL AIRCRAFT, TRANSPORT AIRCRAFT, WORKLOAD, COMPUTER ARCHITECTURE

ID (25) EXPORT CONTROL, PE62201F, WUWL24030498
AB (27) The contents of this final report are provided as a summary of documented cockpit design efforts performed by Midwest System Research, Inc., between March 1989 and March 1993, for the United States Air Force at the Wright Laboratory., Joint Cockpit Office, Wright Patterson Air Force Base, Ohio. The work was performed under contract F3361588-C-3612, Pilot Factors Research for Crew Systems Development (PIFAX). This report summarizes all work accomplished on the contract over a 52-month period. More task specific, detailed information is contained in final reports and other documents for each task. Summary information is provided pertaining to work efforts in the following areas: MAGIC (Micro-Controller Enhanced Tri-Sensor Photometer, Super Switch, Font Studies, Unusual Attitude Recovery Studies, 3-D Cursor Studies, Head Down Display/Standardized Primary Flight Display, Standardized Military HUD, Voice Recognition, Pathway-In-The-Sky Navigation, and Bezel Attitude Indicator Studies) Generic Voice Interface Workstation Development; C-17 Crew Station Design/Evaluation Support; Tactical Aircraft Cockpit; Transport Aircraft Cockpit; FAA Mode-S Data Link; Adaptive Automation Support; SOF Simulation Architecture Definition; Control and Display Criteria; and Modeling the Dynamics of Mental Workload and Pilot Performance. Pilot, HUD, HDD, Pilot factors, ICASS, TACS, IMPACT, TRAC, MAGIC, C-17, SOF, Data link, Mode-S, Cockpit, Special Operations, SOA, Voice, Adaptive automation, Simulation architecture.

AN (1) AD-A276 491/XAG
CA (5) MACAULAY-BROWN INC DAYTON OH
TI (6) Pilot-Centric Design Methodology and Concepts Program: Technical Analytical Study Program.
DN (9) Final rept. Oct 87-Nov 91
AU (10) Teall, Thomas A.
RD (11) Jan 1992
PG (12) 68 Pages
RS (14) M91-P401-1107-A
CT (15) F33615-87-C-0534
RN (18) AL**-SR-1992-0027
XC-AL**
RC (20) Unclassified report
DE (23) *AUDITORY SIGNALS, *COCKPITS, *MAN COMPUTER INTERFACE
COMPUTERS, COUPLINGS, CREWS, ENVIRONMENTS, HUMANS, INTERFACES, LABORATORIES, MACHINES, MEASUREMENT, MEDICAL RESEARCH, METHODOLOGY, MODELS, PERFORMANCE(HUMAN), PERSONNEL, PILOTS, PROTOTYPES, SIGNALS, SIMULATION, STATE OF THE ART, STATIONS, VISUAL SIGNALS, WORK
ID (25) PE62202F, WUAL71842611
AB (27) This report describes the work performed by MacAulay-Brown, Inc. (MacB) to support the Armstrong Aerospace Medical Research Laboratory (AAMRL) Pilot-Centric Design Methodology and Concepts (PDMC) Program. The PDMC Program was established to respond to the need for operator-centered crew stations. The conceptual development of virtual-world technologies, providing a spatial coupling to the visual, aural, and tactile senses, was emphasized during the program. This report details studies, analyses, simulations, and hardware/software prototype evaluations performed by MacB and various subcontracted personnel, in order to develop measurements and models of human performance in tactical and/or strategic environments. In addition, the report describes assessments of state-of-the-art human/machine (sub) systems relating to pilot-centered cockpit interfaces and various conceptual and hardware/software development efforts conducted within the PDMC program. Auditory signals, Cockpits, Display, Man-computer interface, Performance, Visual signals.

AN (1) AD-B134 754/XAG
CA (5) MIDWEST SYSTEMS RESEARCH INC DAYTON OH
TI (6) Tactical Aircraft Cockpit Study (TACS). Volume 1. Phase 2. Switchology Investigation.

DN (9) Final rept. Sep 85-Jul 87
AU (10) Barbato, G. J.
Kovacs, J. A.
RD (11) May 1989
PG (12) 86 Pages
RS (14) MSR-TR-88-01-VOL-1
CT (15) F33615-85-C-3623
RN (18) WRDC-TR-89-7002-VOL-1
RC (20) Unclassified report
AL (22) Distribution authorized to U.S. Gov't. agencies and their contractors; Critical Technology; May 89. Other requests shall be referred to WRDC/KTC, Wright-Patterson AFB, OH 45433. This document contains export-controlled technical data.
DE (23) *COCKPITS, *DISPLAY SYSTEMS, *TACTICAL AIRCRAFT
ADVANCED WEAPONS, AUTOMATION, CONTROL STICKS, CREWS, DATA PROCESSING, FORMATS, HANDBOOKS, HANDS, INPUT, JET FIGHTERS, METHODOLOGY, OPERATION, PERFORMANCE(HUMAN), PILOTS, STATIONS, TEST AND EVALUATION, THROTTLING, VOICE COMMUNICATIONS
ID (25) EXPORT CONTROL, PE62201F, WUWRDC24030460
AB (27) The Tactical Aircraft Cockpit Study (TACS) Phase II evaluation assessed pilot performance and preference using three types of data input techniques: hands on throttle and stick (HOTAS) touch-sensitive CRT screens and voice control. These techniques were analyzed within the framework of a mid-to-late 1990' tactical air-superiority fighter's mission requirements and projected cockpit technologies. Other design issues examined during this study included pilot assessment of required system automation, the use of an articulating seat and the proper implementation and integration of advanced display technology and voice command. The report is divided into two volumes. The first (Switchology Investigation) presents the procedures and results of the evaluation and the cockpit changes recommended by the evaluation subjects. The second volume (Pilot's Handbook) was given to the evaluation subjects prior to the role-playing sessions and provided the material necessary to understand the operation of the cockpit and its capability. Keywords; Advanced tactical fighter; Cockpit concepts; Control execution; Controls and displays; Crew station design; Display formats. (sdw)

AN (1) AD-A213 236/XAG
CA (5) ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT NEUILLY-SUR-SEINE (FRAN CE)
TI (6) Man-Machine Interface in Tactical Aircraft Design and Combat Automation (Conference Proceedings Held in Stuttgart (Germany, F.R.) on 28 September-1 October 1987).
RD (11) Jul 1988
PG (12) 247 Pages
RS (14) AGARD-CP-425
RC (20) Unclassified report
NO (21) Preface in English and French. Presented at Joint GCP/FMP Symposium Stuttgart, Germany.
DE (23) *AUTOMATION, *DISPLAY SYSTEMS, *FIRE CONTROL SYSTEMS, *MAN MACHINE SYSTEMS, *TACTICAL AIRCRAFT, *WEAPON SYSTEM EFFECTIVENESS
AIRCRAFT, AIRFRAMES, ALL WEATHER, AWARENESS, COCKPITS, CONTROL, CREWS, CRITICALITY(GENERAL), FLIGHT CONTROL SYSTEMS, FLIGHT CREWS, FLIGHT PATHS, FUNCTIONS, GERMANY(EAST AND WEST), HEADGEAR, INTEGRATION, INTERFACES, LOW ALTITUDE, MANAGEMENT, NAVIGATION, NIGHT, OPERATION, PILOTS, PROTECTIVE CLOTHING, SEATS, STATIONS, SYMPOSIA, SYSTEMS MANAGEMENT, THREATS, VEHICLES, WARFARE, WEAPON SYSTEMS, WORKLOAD
AB (27) Technological advances have made possible the development of system capabilities which allow more effective weapon system operation under difficult conditions, such as low altitude, high speed, night and all weather. Higher levels of technology integration and combat automation are now becoming essential to enable the pilot to accomplish the critical functions of flight path control, threat management, navigation, attack engagement and weapon system management. Several emerging technologies are now beginning to spawn major innovations in

aircraft design, through the use of combat automation concepts. These technologies carry significant implications in respect of pilot workload, situational awareness, crew station controls and displays, and automated system functions including integrity management. Effective and efficient harmonisation of this total weapon system, which must also achieve the essential features of pilot acceptability and safety, is critically dependent on the pilot/vehicle interface. This symposium sought to address these critical issues of combat automation and the man-machine interface. In particular, it considered the major implications and trade-offs involved in varying levels of airframe and weapon systems sophistication and such fundamental choices as that of single seat versus two seat operation. Keywords: Display systems; Head up displays; Aircrew protective headgear; Fire control systems; Cockpit controls. (KT)

AN (1) AD-A146 922/XAG
CA (5) MCDONNELL AIRCRAFT CO ST LOUIS MO
TI (6) Display Techniques for Advanced Crew Stations (DTACS). Phase 1. Display Techniques Study.
DN (9) Final technical rept. Apr 83-Oct 84
AU (10) Adam,E. C.
Dillard,H. E.
Velten,R. M.
Guenther,J.
RD (11) Mar 1984
PG (12) 130 Pages
CT (15) F33615-83-C-1040
RN (18) AFWAL-TR-84-1016
RC (20) Unclassified report
NO (21) Prepared in cooperation with Hughes Aircraft Co., El Segundo, CA.
DE (23) *Flight crews, *Display systems
Avionics, Jet fighters, Mission profiles, Stations, Military requirements
ID (25) PE62204F, WUAFWAL20030934
AB (27) The DTACS Final Report describes the study which explored advanced display techniques and their effect on future fighter/attack aircraft crew stations. The emphasis was placed on new and developing technology with applications to integrated avionics systems. Future mission requirements were reviewed, display requirements were established, display technologies were reviewed, an initial configuration of an advanced display was made and a plan for further development was also prepared.

AN (1) AD-P002 845/XAG
CA (5) NAVAL AIR DEVELOPMENT CENTER WARMINSTER PA
TI (6) Avionics/Crew Station Integration
AU (10) Mulley,W. G.
RD (11) Oct 1983
PG (12) 9 Pages
RC (20) Unclassified report
NO (21) This article is from 'Advanced Concepts for Avionics/Weapon System Design, Development and Integration: Conference Proceedings of the Avionics Panel Symposium (45th) Held at Ottawa, Canada on 18-22 April 1983,' AD-A138 600, p9-1-9-9.
DE (23) *Avionics, *Display systems, *Man machine systems
Cockpits, Naval aircraft, Integrated systems, Interfaces, Pilots, Flight control systems, Human factors engineering, Bus conductors, Multiplexing, Video signals, Digital systems, Modules(Electronics), Data management, Life cycle costs
ID (25) Crew stations, AIDS(Advanced Integrated Display System), NATO furnished, Component Reports
AB (27) The U.S. Navy has been encouraging advanced development concepts aimed at increasing the aircraft instrumentation performance for multi-platform application of 1990's weapons systems. The system integration (R&D) objectives are to produce a system architecture

easily adaptable to many platforms; technology objectives are to determine the state of the art for displays, electronics, and controls; and the human factors objectives are to determine the proper human-machine interfaces so that the ultimate crew station will be capable of providing the pilot with the proper display and controls performance to satisfy the diverse requirements of fighter, attack, ASW, fixed-wing, rotary-wing, and V/STOL platforms in both a one-man crew of two-man crew matrix. All data/control interfaces among units of this crew station system and other platforms subsystems will be via digital data buses and video multiplex buses. No individual discrete signal, data, or control lines will be needed. This paper discusses the six interfaces necessary to ensure the optimum development of this crew station, the predicted platform mission improvements, and the requisite life-cycle cost considerations. This concept will serve as a basis for planning the integration of the necessary hardware and software features in current and future weapons systems.

AN (1) AD-B261 564/XAG
CA (5) CREARE INC HANOVER NH
TI (6) Haptic Display Software for High Level Architecture Simulations
DN (9) Final rept. 6 Jul 1998-30 Sep 2000
AU (10) Kline-Schoder, Robert J.
Wilson, John P.
RD (11) Dec 2000
PG (12) 128 Pages
RS (14) CREARE-TM-2038A
CT (15) M67004-98-C-0030
RN (18) XY-MCLB/GA
RC (20) Unclassified report
AL (22) Distribution authorized to U.S. Gov't. agencies only; Proprietary Information; Dec 2000. Other requests shall be referred to U.S. Marines Corps, Marine Corps Logistics Base, 814 Radford Blvd, P.O. Drawer 43019, Albany, GA 31704-3019
DE (23) *NEURAL NETS, *DISTRIBUTED INTERACTIVE SIMULATION, *HIGH LEVEL ARCHITECTURE
DATA BASES, SOFTWARE ENGINEERING, INFORMATION EXCHANGE, COMPUTER COMMUNICATIONS, PROTOTYPES, DATA DISPLAYS, INTERACTIVE GRAPHICS, VIRTUAL REALITY, OBJECT ORIENTED PROGRAMMING
ID (25) SBIR(SMALL BUSINESS INNOVATION RESEARCH), HAPTIC DISPLAYS, FORCE FEEDBACK

AN (1) AD-B235 080/XAG
CA (5) CREARE INC HANOVER NH
TI (6) Haptic Display Software for High Level Architecture Simulations
DN (9) Final report 24 Sep 97-24 Mar 98.
AU (10) Kline-Schoder, Robert J.
Wilson, John P.
RD (11) 27 Apr 1998
PG (12) 31 Pages
RS (14) CREARE-TM-1878
CT (15) M67004-97-C-0041
RN (18) XY-MCLB/GA
RC (20) Unclassified report
AL (22) Distribution authorized to U.S. Gov't. agencies only; Proprietary Info; Apr 98 Other requests shall be referred to Marine Corps, Marine Corps Logistics Base, Albany, GA 31704-3019
DE (23) *COMPUTER PROGRAMS, *ALGORITHMS, *COMPUTERIZED SIMULATION, *COMPUTER ARCHITECTURE
KINEMATICS, DATA BASES, REQUIREMENTS, TIME INTERVALS, COMPUTATIONS, INFORMATION EXCHANGE, DISTRIBUTED DATA PROCESSING, MODELS, REAL TIME, PASSIVE SYSTEMS, TRANSMISSION LINES, FEEDBACK, COMMUNICATIONS NETWORKS, DELAY, BANDWIDTH, VIRTUAL REALITY, FORCE(MECHANICS)
ID (25) *HAPTIC DISPLAYS, HLA(HIGH LEVEL ARCHITECTURE)

AN (1) AD-A357 190/XAG
CA (5) WRIGHT STATE UNIV DAYTON OH DEPT OF PSYCHOLOGY
TI (6) Instrumentation to Enhance DoD-Relevant Research on Cognitive Workload in UAVs, Image, Exploitation, and Spatial Hearing.
DN (9) Rept. for 1 Mar 97-28 Feb 98
AU (10) Gilkey, Robert H.
RD (11) Feb 1998
PG (12) 10 Pages
RS (14) WSU-662828
CT (15) F49620-97-1-0118
RN (18) AFRL-SR-BL-TR-98-0840
XC-AFRL-SR-BL
RC (20) Unclassified report
DE (23) *COMPUTERIZED SIMULATION, *DISPLAY SYSTEMS, *VIRTUAL REALITY REAL TIME, TEST EQUIPMENT, INSTRUMENTATION, INTERACTIVE GRAPHICS, WORKLOAD, STEREOSCOPIC DISPLAY SYSTEMS
ID (25) *VERITAS(VIRTUAL ENVIRONMENT RESEARCH INTERACTIVE TECHNOLOGY AND SIMULATION), HAPTIC DISPLAYS, UAV(UNMANNED AERIAL VEHICLES), AUDITORY DISPLAYS, VISUAL DISPLAYS
AB (27) The project goals have been to provide enhanced real-time graphics generation capacity, computational power, and real-time audio signal processing capability for the Virtual Environment Research, Interactive Technology, And Simulation (VERITAS) facility, making it better suited to the demands of DoD-relevant research projects on human performance in complex environments. VERITAS is owned by Wright State University, but housed at Wright-Patterson AFB. It includes a CAVE(Trademark), which is an immersive, wide field-of-view, stereoscopic, real-time interactive display system, allowing the user to move through virtual environments with minimal encumbrances. The CAVE(Trademark) is controlled by a Silicon Graphics Onyx(trademark) computer with InfiniteReality(Trademark) graphics. The high-fidelity simulations in this facility allow a variety of questions related to human effectiveness to be addressed. The DURIP funds were used to purchase three, high-performance computer subsystems: a multiprocessor computational subsystem, a graphics generation subsystem, and an acoustics generation subsystem. These subsystems provide critical capabilities for computationally intensive, real-time-constrained applications, including simulation, virtual environments, auditory and visual displays, motor control, and human perception and cognition. This instrumentation has supported specific funded DoD projects investigating: (1) display and control representations for UAV operation, and (2) binaural and spatial hearing.

AN (1) AD-A366 101/XAG
CA (5) VIRGINIA POLYTECHNIC INST BLACKSBURG
TI (6) Advanced Interface Design Using Force Feedback Hand Controllers, Wearable Computers, and Augmented and Virtual Reality Displays.
DN (9) Final rept. 1 Mar 97-2 Feb 98
AU (10) Barfield, Woodrow
RD (11) 02 Feb 1998
PG (12) 6 Pages
CT (15) N00014-97-1-0388
RN (18) XB-ONR
RC (20) Unclassified report
DE (23) *COMPUTERS, *DISPLAY SYSTEMS, *MAN COMPUTER INTERFACE, *VIRTUAL REALITY CONTROL SYSTEMS, RESEARCH FACILITIES, FEEDBACK, WORK STATIONS, HELMET MOUNTED DISPLAYS
AB (27) The objective of the grant was to establish a research laboratory to design and evaluate augmented and virtual reality environments, wearable computers, and haptic displays. To complete these objectives, SGI workstations, force feedback hand controllers, head-mounted displays, wearable computers, a large-screen projection system, and NT workstations were purchased.

AN (1) AD-A328 767/XAG
CA (5) LOGICON TECHNICAL SERVICES INC DAYTON OH
TI (6) An Evaluation of Advanced Multisensory Display Concepts for use in Future Tactical Aircraft.
DN (9) Interim rept. for Mar 95-Jun 96
AU (10) Haas, Michael W.
Beyer, Steven L.
Dennis, Leon B.
Brickman, Bart J.
Hettinger, Lawrence J.
RD (11) Mar 1997
PG (12) 222 Pages
CT (15) F41624-94-D-6000
PJ (16) 7184
TN (17) 19
RN (18) AL/CF-TR-1997-0049
XC-AL/CF
RC (20) Unclassified report
NO (21) Prepared in cooperation with FCI Associates, Inc., Beavercreek, OH 45432.
DE (23) *FLIGHT TESTING, *MULTISENSORS, *TACTICAL AIRCRAFT, *HELMET MOUNTED DISPLAYS, *HEAD UP DISPLAYS
SCENARIOS, NATO, STATIONS, SIMULATION, RATIOS, SURVIVABILITY, COCKPITS, FLIGHT CREWS, PERFORMANCE(HUMAN), AIRBORNE, INTERCEPTION, PILOTS, ATTACK, REPORTS, TRACKING, HUMAN FACTORS ENGINEERING, THREE DIMENSIONAL, AERIAL WARFARE, MISSIONS, JET FIGHTERS, FLEETS(SHIPS), LETHALITY, WORKLOAD, QUESTIONNAIRES, AWARENESS, AIR TO AIR
ID (25) *HEAD DOWN DISPLAYS, *HAPTIC DISPLAYS, F-15 AIRCRAFT, F-16 AIRCRAFT, SITUATION AWARENESS, PE62202F, WUAL71841901
AB (27) Pilots from three NATO countries participated in simulated air combat scenarios in which they either flew a conventional cockpit, consisting of F-16/F-15 type cockpit displays, or a virtually-augmented cockpit, consisting of advanced head down/head up displays, helmet mounted displays/trackers, 3 dimensional auditory displays, and haptic displays. Pilots flew simulated air intercept missions against a four-ship ground attack group supported by two air to air adversary fighters. The pilot flying the principal cockpit was instructed to try to shoot down the ground-attack group and return to a pre-defined safe air space without being shot down by adversary aircraft. The degree to which pilot performance was differentially affected by the conventional versus virtually-augmented cockpit manipulation was assessed using objective and subjective measures including pilot-aircraft lethality/survivability, pilot workload, and pilot situation awareness. Results indicated a significant advantage for the virtually-augmented interface condition in the number of missions won, exchange ratio, mission length, and number of ground strikes. In addition, the performance improvements yielded by the virtually-augmented crew station were realized with enhanced situation awareness and a reduction in workload compared to the conventional crew station. Furthermore, post flight debrief questionnaires produced highly favorable subjective reports from pilots.

AN (1) AD-A297 231/XAG
CA (5) IMMERSION HUMAN INTERFACE CORP SAN JOSE CA
TI (6) Haptic Interface for Virtual Reality Simulation and Training. Phase 1.
DN (9) Final technical rept. 1 Nov 94-30 Apr 95
AU (10) Rosenberg, Louis B.
Lacey, T. A.
Stredney, D.
RD (11) 30 Jun 1995
PG (12) 78 Pages
CT (15) F49620-94-C-0081
PJ (16) STTR
TN (17) TS
RN (18) AFOSR-TR-95-0482
XC-AFOSR

RC (20) Unclassified report
DE (23) *INTERACTIVE GRAPHICS, *VIRTUAL REALITY, *MEDICAL COMPUTER APPLICATIONS
MATHEMATICAL MODELS, COMPUTERIZED SIMULATION, SOFTWARE ENGINEERING, SIMULATORS, OPTIMIZATION, COMPUTER AIDED DESIGN, TRAINING, LOW COSTS, ONE DIMENSIONAL, RESOLUTION, FEEDBACK, COMPUTER GRAPHICS, MANUAL OPERATION, VISUAL PERCEPTION, DATA DISPLAYS, MAN COMPUTER INTERFACE, DESIGN CRITERIA, SURGERY, SENSES(PHYSIOLOGY), ANALGESIA
ID (25) PE65502F, WUAFOSRSTTRTS
AB (27) Advances in graphic display technologies have made virtual reality (VR) and scientific visualization applications accessible to a wide user population. Unfortunately, few human interface tools exist to allow users to interact naturally with these powerful graphical environments.
To address this need, Immersion Corporation has developed a user interface mechanism to allow natural manual interaction with 3-D environments which provides realistic force feedback to the user. This haphic display methodology combines high fidelity, low cost, and inherent safety to allow force reflection technology to become commercially feasible. The long term objective is to produce a 3-D haptic interface for virtual environments. Phase 1 focused on producing one-dimensional haptic interface hardware and incorporating this technology into a real world VR application. Immersion and the Ohio Supercomputer Center have worked together to produce a virtual simulation of epidural analgesia, a medical procedure that requires delicate needle insertions into the spinal column. The resulting VR simulation is so realistic in look and feel, it can actually be used as a training environment to teach doctors to perform the dexterous manual procedure, allowing them to learn manual technique and explore the associated physical sensations without the risks or costs associated with using real biological specimens. (AN)

AN (1) AD-A228 524/XAG
CA (5) NORTH CAROLINA UNIV AT CHAPEL HILL DEPT OF COMPUTER SCIENCE
TI (6) Project GROPE-Haptic Displays for Scientific Visualization
AU (10) Brooks, Frederick P., Jr.
Ming, Ouh-Young
Batter, James J.
Kilpatrick, P. J.
RD (11) Aug 1990
PG (12) 9 Pages
RC (20) Unclassified report
NO (21) Pub. in Computer Graphics, v24 n4 p177-185 Aug 90.
DE (23) *CHEMISTS
AUGMENTATION, DISPLAY SYSTEMS, DOCKING, DOCKS, DRUGS, GLOBAL, INTERACTIONS, MODELS, MOLECULES, PERCEPTION, PROTEINS, VISUAL AIDS
AB (27) We began in 1967 a project to develop a Haptic + display for 6-D force fields of interacting protein molecules. We approached it in four stages: a 2-D system, a 3-D system tested with a simple task, a 6-D system tested with a simple task, and a full 6-D molecular docking system, our initial goal. This paper summarizes the entire project--the four systems, the evaluation experiments, the results, and our observations. The molecular docking system results are new. Our principal conclusions are: Haptic display as an augmentation to visual display can improve perception and understanding both of force field and of world models populated with impenetrable objects. Chemists using GROPE-III can readily reproduce the true docking positions for drugs whose docking is known (but not to them) and can find very good docks for drugs whose true docks are unknown. The present tool promises to yield new chemistry research results; it is being actively used by research chemists. (js)

AN (1) AD- 783 690/XAG
CA (5) SANDERS ASSOCIATES INC NASHUA N H
TI (6) Tactile Display for Aircraft Control.
DN (9) Semi-annual technical rept. 1 Jan-30 Jun 74
AU (10) Rosa,Don H.

Sanneman,Richard A.
Levison,William H.
Berliner,Jeffrey E.
RD (11) 30 Jun 1974
PG (12) 94 Pages
CT (15) N00014-73-C-0031, ARPA Order-2108
PJ (16) NR-196-123
RC (20) Unclassified report
NO (21) Prepared in cooperation with Bolt Beranek and Newman, Inc., Cambridge, Mass. Behavioral Science Div. See also report dated Jan 73, AD-757 344.
DE (23) *Flight control systems, *Display systems, *Touch, *Instrument flight Control panels, Skin(Anatomy), Senses(Physiology), Perception, Stimulation(Physiology), Electric current, Vibration, Intensity, Pilots
ID (25) *Tactile instrumentation, *Tactile display systems
AB (27) The program was directed towards the development of tactile displays for flight control. The results of the first phase of this program have been reported in the August '73 Final Report (AD-767 763). The report presents a description of an improved tactile display system and its evaluation as a one and two axis error display instrument during a series of manual tracking experiments. Both electrotactors and vibrotactors arrays were used. These experiments were run to obtain modeling data to predict the display performance during the forthcoming F-4 simulator evaluation phase of the program. The tracking error scores for the new tactile display are better than for the initial system. Of the four subjects employed during these tests, two preferred the electrotactor array because it provides a more clearly perceptable haptic display. (Modified author abstract)

AN (1) AD-A367 318/XAG
CA (5) ARMY AEROMEDICAL RESEARCH LAB FORT RUCKER AL
TI (6) Concept Phase Evaluation of the Microvision, Inc. Aircrew Integrated Helmet System HGU-56P Virtual Retinal Display
DN (9) Final rept.
AU (10) Rash, Clarence E.
Harding, Thomas H.
Martin, John S.
Beasley, Howard H.
RD (11) Aug 1999
PG (12) 27 Pages
RS (14) USAARL-99-18
PJ (16) 30162787A879
RN (18) XA-USAMRMC
RC (20) Unclassified report
DE (23) *VISUAL PERCEPTION, *HELMET MOUNTED DISPLAYS, *DIODE LASERS TEST AND EVALUATION, SOURCES, OPTICAL PROPERTIES, PROTOTYPES, VERTICAL ORIENTATION, LUMINANCE
ID (25) PE62787A, WUDA336445
AB (27) In support of the RAH-66 Comanche, Microvision Inc., Seattle, Washington, has developed a prototype helmet mounted display based on laser diode sources. This prototype has been evaluated for optical and visual performance. Tests include: exit pupil size and shape, eye relief, field-of-view, luminance, contrast, contrast transfer function(CTF), modulation transfer function(MTF), and interpupilary distance and vertical adjustments.

AN (1) AD-A170 348/XAG
CA (5) SEACO INC KAILUA HI
TI (6) Perception of Depth with Stereoscopic Combat Displays.
DN (9) Final rept. Dec 83-Aug 84
AU (10) Nishijo,R. Y.
RD (11) Mar 1986
PG (12) 126 Pages
CT (15) N00123-82-D-0059
RN (18) NOSC-CR-348

RC (20) Unclassified report
DE (23) *VISUAL PERCEPTION, *STEREOSCOPIC DISPLAY SYSTEMS
VIEWERS, TELEVISION SYSTEMS, DEPTH, PERFORMANCE(HUMAN)
ID (25) *Depth perception, *Combat displays, Land combat, PE6275N, WUDN388512
AB (27) A series of four experiments was conducted to investigate the independent and interactive effects of three video system parameters on the scaling of depth intervals viewed through stereoscopic (stereo) combat display systems. Experiment One investigated the effects of interaxial separation and lens magnification. Experiments Two investigated the effects of camera convergence. Experiments Three and Four partially replicated the video system used in Experiment One under more complex scene conditions. For all experiments, ocular fatigue induced by various combinations of system parameters was also measured. For Experiments One, Two, and Three, stereoscopic imagery produced depth interval estimates which were superior to those found under monoscopic viewing conditions. In addition, increasing camera separation and thereby increasing retinal disparities beyond natural stereo values improved depth interval estimation. Camera convergence exerted a significant effect with convergence in front of the area of interest providing greatest accuracy. Lens mangification was not found to exert a significant influence on depth interval estimation. No evidence of ocular fatigue was found under any conditions tested in any of the experiments. (Author)

AN (1) AD- 770 993/XAG
CA (5) AEROSPACE MEDICAL RESEARCH LAB WRIGHT-PATTERSON AFB OHIO
TI (6) Psychological Considerations in the Design of Helmet-Mounted Displays and Sights: Overview and Annotated Bibliography.
DN (9) Final rept.
AU (10) Hughes,Richard L.
Chason,L. Ralph
Schwank,Jock C. H.
RD (11) Aug 1973
PG (12) 95 Pages
RS (14) AMRL-TR-73-16
PJ (16) AF-7184
TN (17) 718404
RC (20) Unclassified report
DE (23) *Display systems, *Cockpits, *Helmets, *Sights
Psychology, Bibliographies, Retina, Brightness, Vision, Man machine systems, Cathode ray tubes
ID (25) *Eye dominance, *Retinal rivalry, Visual coupling systems, *Helmet mounted displays, *Helmet mounted sights
AB (27) An overview of the history and the known and potential psychological problems of helmet-mounted displays is followed by an extensive annotated bibliography of relevant material arranged by topics: eye dominance, brightness disparity, helmet-mounted displays/helmet-mounted sights, retinal rivalry, and the AMD visually-coupled systems symposium (of 1972). The bibliography annotations, which vary in length from one sentence to one-half of a page, describe the contents of the articles but do not evaluate them. Most of the bibliographic entries are not listed in previously published articles on helmet-mounted displays and/or sights. (Author)

AN (1) AD-B189 240/XAG
CA (5) MAN-MADE SYSTEMS CORP ELLICOTT CITY MD
TI (6) Telectrode Systems for Unobtrusive, Biopotential Recordings.
DN (9) Final technical rept. 17 May-17 Dec 93
AU (10) Horst, Richard L.
Blaumanis, Otis R.
Faulk, Steven M.
Mills, William J.
RD (11) Jun 1994
PG (12) 53 Pages
RS (14) F41624-93-C-2005

PJ (16) 3005
TN (17) AC
RN (18) AL/AO-TR-1994-0054
XC-AL/AO
RC (20) Unclassified report
AL (22) Distribution authorized to U.S. Gov't. agencies only; Proprietary Info.; 23 May 94. Other requests shall be referred to AL/XPPL, 2509 Kennedy Circle, Brooks AFB, TX 78235-5118. This document contains export-controlled technical data.
DE (23) *PSYCHOPHYSIOLOGY
ADHESIVES, AMPLIFICATION, BREAD, CIRCUITS, ELECTRODES, ELECTRONICS, HUMANS, INTERFACES, LABORATORIES, LOW VOLTAGE, NOISE, NOISE(ELECTRICAL AND ELECTROMAGNETIC), PARAMETERS, PHASE, PHYSIOLOGY, PROFILES, PROTOTYPES, RECEIVERS, SELF CONTAINED, SIGNALS, SURFACES, TIME, TRANSDUCERS, VOLTAGE, WIRE
ID (25) *Biotelemtry, PE65502F, WUAL3005AC3D, SBIR, EXPORT CONTROL

AN (1) AD-B256 201/XAG
CA (5) GENEX TECHNOLOGIES INC KENSINGTON MD
TI (6) A High-Resolution Volumetric 3-D Display System for Pilot Training
DN (9) Interim rept. May 1998-Feb 1999
AU (10) Geng, Jason
RD (11) Dec 1999
PG (12) 30 Pages
RS (14) GTI-SBIR-9805
CT (15) F41624-98-C-5021
PJ (16) 3005
TN (17) HA
RN (18) AFRL-HE-AZ-TR-1999-0205
XC-AFRL-HE-AZ
RC (20) Unclassified report
AL (22) Distribution authorized to DoD only; Proprietary Info.; 1 Dec 99. Other requests shall be referred to AFRL/HEA, 6030 South Kent St., Bldg 561, Mesa AZ 85212-6061.
DE (23) *FLIGHT TRAINING, *COMPUTER AIDED INSTRUCTION
PILOTS, LIQUID CRYSTALS, AIR FORCE TRAINING, THREE DIMENSIONAL, MAN COMPUTER INTERFACE, LIGHT MODULATORS, TELEVISION DISPLAY SYSTEMS, HIGH DEFINITION TELEVISION, SCENE GENERATION
ID (25) VOLUMETRIC DISPLAYS, SPATIAL LIGHT MODULATORS, SBIR(SMALL BUSINESS INNOVATION RESEARCH), PE65502F, WUAFRL3005HA8D

AN (1) AD-D019 565/XAG
CA (5) DEPARTMENT OF THE NAVY WASHINGTON DC
TI (6) Computer Program for a Three-Dimensional Volumetric Display
DN (9) Patent, Filed 2 Oct 96, patented 31 Aug 99
AU (10) Acantilado, Nell P.
RD (11) 31 Aug 1999
PG (12) 9 Pages
RS (14) PAT-APPL-08 726 305, PATENT-5 945 966
RN (18) XB-SEC/NAV
RC (20) Unclassified report
AL (22) Availability: This Government-owned invention available for U.S. licensing and possibly, for foreign licensing. Copy of patent available Commissioner of Patents, Washington, DC 20231.
DE (23) *COMPUTER PROGRAMS, *PATENTS, *STEREOSCOPIC DISPLAY SYSTEMS
DEFLECTORS
ID (25) PAT-CL-345-6, VOLUMETRIC DISPLAYS, BEAM DEFLECTORS
AB (27) A method for transforming world coordinates into device coordinates comprises the steps of inputting a set of world coordinates to be displayed, scaling the world coordinates into view coordinates bounded by a display volume, finding a control memory location of a light beam deflector corresponding to a Y-axis position for each of the view coordinates, calculating X-axis and Z-axis device coordinates from the view coordinates for deflecting a light beam to a selected point within the display volume corresponding to each of the view coordinates, and

loading the device coordinates into the control memory locations corresponding to the Y-axis position for each of the view coordinates to cause the light beam to be deflected to each selected point.

AN (1) AD-D019 533/XAG
CA (5) DEPARTMENT OF THE NAVY WASHINGTON DC
TI (6) Electroluminescent Arrays Layered to Form a Volumetric Display
DN (9) Patents, Filed 19 Sep 96, patented 27 Jul 99
AU (10) Whitesell, Eric J.
RD (11) 27 Jul 1999
PG (12) 8 Pages
RS (14) PAT-APPL-08 715 979, PATENT-5 929 572
RN (18) XB-SEC/NAV
RC (20) Unclassified report
AL (22) Availability: This Government-owned invention available for U.S. licensing and possibly, for foreign licensing. Copy of patent available Commissioner of Patents, Washington, DC 20231.
DE (23) *PATENTS, *STEREOSCOPIC DISPLAY SYSTEMS
ELECTROLUMINESCENCE, TRANSPARENCE, ELECTRODES
ID (25) PAT-CL-315-169.3, *SOLID STATE DISPLAYS
AB (27) A solid state 3-D display comprises an array of voxels made of an electroluminescent material arranged in a matrix of a transparent material. Transparent electrodes are formed in the matrix to form electrical connections to each voxel. The transparent electrodes are connected to voltage sources outside the display volume for controlling the optical output of each voxel to produce a three-dimensional image inside the display volume.

AN (1) AD-B244 302/XAG
CA (5) SY TECHNOLOGY INC HUNTSVILLE AL
TI (6) Full-Complex Wavefront Generation for 3-D Volumetric Holographic Displays
DN (9) Final rept. May 98-Feb 99
AU (10) Erbach, Peter S.
RD (11) Mar 1999
PG (12) 52 Pages
CT (15) F41624-98-C-5033
PJ (16) 3005
TN (17) HC
RN (18) AFRL-HE-WP-TR-1999-0009
XC-AFRL-HE-WP
RC (20) Unclassified report
AL (22) Distribution authorized to U.S. Gov't. agencies only; Proprietary Info; Mar 99 Other requests shall be referred to AFRL/HECV, Wright Patterson AFB OH 45433-7022
DE (23) *HOLOGRAPHY, *WAVEFRONTS, *STEREOSCOPIC DISPLAY SYSTEMS
COMPUTER GRAPHICS, LIGHT MODULATORS, HEAD UP DISPLAYS, WAVEFORM GENERATORS
ID (25) PE65502F, WUAFRL3005HC8M

AN (1) AD-A358 303/XAG
CA (5) SPACE AND NAVAL WARFARE SYSTEMS COMMANDSAN DIEGO CA
TI (6) Improved Second-Generation 3-D Volumetric Display System. Revision 2
AU (10) Soltan, P.
Lasher, M.
Dahlke, W.
McDonald, M.
Acantilado, N.
RD (11) Oct 1998
PG (12) 263 Pages
RS (14) SPAWAR-TR-1763-REV-2
RN (18) XB-SPAWAR/CA
RC (20) Unclassified report

NO (21) Supersedes AD-A355 592. Original contains color plates: All DTIC reproductions will be in black and white.
DE (23) *COMPUTER GRAPHICS, *VIRTUAL REALITY, *STEREOSCOPIC DISPLAY SYSTEMS COMPUTERIZED SIMULATION, LASER BEAMS, THREE DIMENSIONAL, VISUAL PERCEPTION
ID (25) *VOLUMETRIC DISPLAYS
AB (27) The Space and Naval Warfare (SPAWAR) Systems Center, San Diego (SSC San Diego) Simulation and Human Technology Division has developed and improved its second generation 3-D Volumetric Display System for displaying data, information, and scenes in a three dimensional volume of image space. The system has good potential for many military and commercial applications. Based on a computer controlled laser optics system that projects three laser beams simultaneously onto a 36-inch diameter/18-inch high double helix spinning at 600 revolutions per minute, this system presents 3-D images in an addressable 10 cubic feet of cylindrical volume. This report discusses the four basic disciplines used in development of the Improved Second Generation 3-D Volumetric Display System and provides examples of practical applications of the technology.

AN (1) AD-B233 372/XAG
CA (5) LASER POWER RESEARCH SAN DIEGO CA
TI (6) Microlaser-Based Three Dimensional Display
DN (9) Final rept.
AU (10) Fink, Charles
Bergstedt, Robert
RD (11) 04 Feb 1998
PG (12) 16 Pages
RS (14) 30057
CT (15) DAAH01-97-C-R171, ARPA ORDER-611
RN (18) XA-AMSMI
RC (20) Unclassified report
AL (22) Distribution authorized to U.S. Gov't. agencies only; Test and Evaluation; 4 Feb 98. Other requests shall be referred to Defense Advanced Research Projects Agency, 3701 N. Fairfax Dr., Arlington, VA 22203-1714.
DE (23) *LASER APPLICATIONS, *COLOR DISPLAYS
HIGH RESOLUTION, THREE DIMENSIONAL, MULTIPURPOSE, LIGHT MODULATORS
ID (25) VOLUMETRIC DISPLAYS, SBIR(SMALL BUSINESS INNOVATION RESEARCH), *THREE DIMENSIONAL DISPLAYS, MICROLASERS, VOXELS, SPATIAL LIGHT MODULATORS
AB (27) Report developed under SBIR contract. A first step has been completed toward implementing a three dimensional display capability for complex, multi-dimensional information. By combining microlaser based full color display technology developed by Laser Power Corporation (LPC) with a three dimensional display monitor developed by Specialty Devices Incorporated (SDI), LPC assembled and demonstrated a 16 x 16 x 16 voxel test bed that displayed fully recognizable static and dynamic images in monochrome, white and full color. Additional work in this Phase 1 SBIR effort included determining three dimensional display requirements for a variety of applications. These included military applications such as the Army's virtual sand table, to be used in the Command Post of the Future, and the Navy's horizontal large screen display, medical diagnostics applications such as three dimensional viewing of CAT and PET scans, air traffic control displays and entertainment applications such as volumetric video and computer games. Based on the Phase 1 test bed success and the results of the requirements review, LPC is prepared to continue with a Phase 2 effort to develop a two million voxel display demonstration device based on an advanced microlaser based display system and an enhanced three dimensional monitor.

AN (1) AD-B232 303/XAG
CA (5) GENEX TECHNOLOGIES INC ROCKVILLE MD
TI (6) A Novel Three-Dimensional Visual System. SBIR Phase 1.
DN (9) Final rept. 5 Jun-5 Dec 97
AU (10) Geng, Jason

RD (11) 21 Dec 1997
PG (12) 44 Pages
RS (14) DARPA-3D-9701
CT (15) DAAH01-97-C-R169
RN (18) XT-DARPA
RC (20) Unclassified report
AL (22) Distribution authorized to U.S. Gov't. agencies only; Proprietary Info.; Dec 97. Other requests shall be referred to Defense Advanced Research Projects Agency/ETO, 3701 N. Fairfax Dr., Arlington, VA 22203-1714.
DE (23) *STEREOSCOPIC DISPLAY SYSTEMS, *TELEVISION DISPLAY SYSTEMS
IMAGE PROCESSING, PARALLEL PROCESSING, PROTOTYPES, HIGH RESOLUTION, THREE DIMENSIONAL, PIXELS, LIGHT MODULATORS, SCREENS(DISPLAYS)
ID (25) SBIR(SMALL BUSINESS INNOVATION RESEARCH), HDTV(HIGH DEFINITION TELEVISION), *VOLUMETRIC DISPLAYS, THREE DIMENSIONAL DISPLAYS, SPATIAL LIGHT MODULATORS

AN (1) AD-A328 337/XAG
CA (5) GEORGE MASON UNIV FAIRFAX VA CENTER FOR COMPUTATIONAL STATISTICS
TI (6) Instrumentation in Support of Interactive Visualization, Computation and Simulation.
DN (9) Final progress rept. 1 Nov 94-31 Oct 95
AU (10) Wegman, Edward J.
RD (11) 01 Jun 1997
PG (12) 7 Pages
CT (15) DAAH04-95-1-0009
RN (18) ARO-33720.1-MA-RIP
XA-ARO
RC (20) Unclassified report
DE (23) *COMPUTERIZED SIMULATION, *VIRTUAL REALITY
IMAGE PROCESSING, DATA MANAGEMENT, MINE COUNTERMEASURES, MINE DETECTION, COMPUTER GRAPHICS, COMPUTER VISION, DATA DISPLAYS, INTERACTIVE GRAPHICS, HELMET MOUNTED DISPLAYS
AB (27) This research accomplished as a result of this effort focused on the alliance of elements of virtual reality technology and elements of scientific visualization to address issues of mine detection and related spatial and volumetric visualization problems. By virtual environments, we meant an immersive visual and audio technology such that experimenter has little or no awareness of the real environment. For our purposes of data visualization, this was intended as a focusing devise so that the experimenter has a heightened sense of awareness of the problem at hand thus, can concentrate in a natural way his or her full mental resources. Much of currently fashionable work on scientific visualization bad been focused on rendering on flow fields arising from combustion or meteorological applications, molecular, atomic or subatomic particle dynamics, and other settings modeled with partial differential equation models. Our focus had been, in contrast, or data representation, exploratory data analysis and model building using high performance computer graphics, much of which has recently emerged under the name data mining.

AN (1) AD-B232 849/XAG
CA (5) THREE D TECHNOLOGY LABS MOUNTAIN VIEW CA
TI (6) A Novel Three-Color, Solid State, 3D Display
DN (9) Final rept. 16 Sep 96-23 Jun 97
AU (10) Downing, Elizabeth
RD (11) Jun 1997
PG (12) 28 Pages
CT (15) F33615-96-C-1950
PJ (16) OAFE
TN (17) 01
RN (18) WL*-TR-97-1204
XC-WL*
RC (20) Unclassified report
AL (22) Distribution authorized to U.S. Gov't. agencies only; Proprietary

Info.; Jun 97. Other requests shall be referred to Wright Laboratory/AASA, Wright-Patterson AFB, OH 45433-7623.
DE (23) *LASER BEAMS, *STEREOSCOPIC DISPLAY SYSTEMS
IMAGE PROCESSING, REAL TIME, THREE DIMENSIONAL, INFRARED LASERS, COLOR DISPLAYS, PIXELS
ID (25) *VOLUMETRIC DISPLAYS, SBIR(SMALL BUSINESS INNOVATION RESEARCH), THREE DIMENSIONAL DISPLAYS, VOXELS, PE62173F, WUWLOAFE0124

AN (1) AD-B221 857/XAG
CA (5) DIMENSIONAL MEDIA ASSOCIATES NEW YORK
TI (6) High Definition Image Volume Display, R&D Status Report.
DN (9) Final rept.
AU (10) Prince, Jonathan
RD (11) 06 Jan 1997
PG (12) 159 Pages
CT (15) MDA972-96-C-0015, DARPA ORDER-A917
RN (18) XA-AMSMI/RD
RC (20) Unclassified report
AL (22) Distribution authorized to U.S. Gov't. agencies and private individuals or enterprises eligible to obtain export-controlled technical data in accordance with DoDD 5230.25 6 Jan 97. Controlling DoD office is US Army Missile Command, Attn: AMSMI-RD-WSDP-SB, Redstone Arsenal, AL 35898., Availability: Document partially illegible.
DE (23) *LASER BEAMS, *COMPUTER GRAPHICS, *VIRTUAL REALITY, *STEREOSCOPIC DISPLAY SYSTEMS
COMPUTERIZED SIMULATION, SOFTWARE ENGINEERING, IMAGE PROCESSING, HIGH RESOLUTION, BEAM SPLITTING, THREE DIMENSIONAL, LASER APPLICATIONS, LIQUID CRYSTAL DISPLAY SYSTEMS, COLOR DISPLAYS, MAN COMPUTER INTERFACE, ACOUSTOOPTICS, PIEZOELECTRIC TRANSDUCERS, VOLTAGE CONTROLLED OSCILLATORS, FLICKER, VIDEO INTEGRATION
ID (25) SBIR(SMALL BUSINESS INNOVATATION RESEARCH)
AB (27) This document is the final report for this SBIR phase 2 development effort. The goal of this project was to develop a prototype three dimensional display based upon the Multiplanar Volumetric Display (MVD) technology of Dimensional Media Associates, Inc. The MVD concept will enable the production of high resolution, full color, three dimensional images which actually float in the air out in front of the display. The images have a wide field of view and are truly 3D, that is, the 3D image is not created by manipulating the visual perceptions of the viewer. Furthermore, the fact that the image floats in free space, and is not confined within the display, permits a virtual interaction with the image. The 3D image may actually be touched and manipulated through the use of a force feedback interface enabling a truly unique interface modality. A schematic diagram of the prototype MVD is shown.

AN (1) AD-A312 398/XAG
CA (5) NAVAL COMMAND CONTROL AND OCEAN SURVEILLANCE CENTER RDT AND E DIV SAN DIEGO CA
TI (6) Laser Projected 3-D Volumetric Displays
AU (10) Lasher, M.
Soltan, P.
Dahlke, W.
Acantilado, N.
McDonald, M.
RD (11) Jul 1996
PG (12) 13 Pages
RN (18) XB-ONR
RC (20) Unclassified report
AL (22) Availability: Pub. in Projection Displays II, SPIE V2650 p285-295 1996. Available only to DTIC users. No copies furnished by NTIS.
DE (23) *COLOR DISPLAYS, *STEREOSCOPIC DISPLAY SYSTEMS
SOFTWARE ENGINEERING, REPRINTS, LASER BEAMS, GRIDS(COORDINATES), THREE DIMENSIONAL, COORDINATES, FORMATS, OPTICAL SCANNING, ENVELOPE(SPACE), VIEWERS, HELIXES, PARALLAX COMPUTERS
ID (25) *VOLUMETRIC DISPLAYS, VOXELS, PE62122N

AB (27) A three dimensional volumetric display system utilizing a rotating helical surface is described. The rotating helix system permits images be displayed in a three dimensional format that can be observed without the use of special glasses. Its rotating helical screen sweeps out a cylindrical envelope, providing a volumetric display medium through which scanned laser pulses are projected. The light scatters from the surface of the helix so that each voxel appears to emanate from specific points in space. Each point has x-y coordinates determined by the laser scanner and a z coordinate determined by the intersection of the laser beam and the helix surface. Display images are created by synchronizing the interaction of the laser pulses and the moving screen to address a full three dimensional volume that gives the viewer true depth cues (binocular parallax, accommodation, convergence) without the need for any special viewing aids. We describe recent work on the development of mechanical, optical, electronic, and software engineering for a display system based on a 36-inch diameter helix using high speed, multichannel, random access laser scanners. Color images are created using red, green, and blue laser sources. The system is capable of displaying 800,000 voxels per second, per color. A portable, 12-inch diameter, translucent helix system is also present.

AN (1) AD-A306 215/XAG

CA (5) NAVAL COMMAND CONTROL AND OCEAN SURVEILLANCE CENTER RDT AND E DIV SAN DIEGO CA

TI (6) Laser-Based 3-D Volumetric Display System (The Improved Second Generation).

AU (10) Soltan, P.
Trias, J.
Dahlke, W.
Lasher, M.
McDonald, M.

RD (11) Mar 1996

PG (12) 27 Pages

RN (18) XB-ONR

RC (20) Unclassified report

DE (23) *THREE DIMENSIONAL, *IMAGES, *COLOR DISPLAYS, *DATA DISPLAYS, *VOLUMETRIC ANALYSIS
CONTROL, REAL TIME, COMPUTERS, REFLECTION, LASER BEAMS, HIGH RESOLUTION, SURFACES, GRIDS(COORDINATES), LASER APPLICATIONS, CYLINDRICAL BODIES, COORDINATES, COLORS, DISCRETE DISTRIBUTION, HEIGHT, ACOUSTOOPTICS, OCEAN SURVEILLANCE, HELIXES

ID (25) *VOXELS, PE62122N, WUDN303196

AB (27) NRaD, the RDT&E Division of the Naval Command, Control and Ocean Surveillance Center (NCCOSC), has developed and improved its second-generation device for displaying data, information, and scenes in a three-dimensional volume of image space. The device incorporates a 36-inch diameter double helix that spins at approximately 10 revolutions per second, providing a means to address a cylindrical volume. Under computer control, a laser beam is directed to illuminate certain discrete volume points (voxels) on the helix needed to create a scene. The laser light scatters from the surface of the helix, so, to the observer, each voxel appears to emanate from specific points in space. Each point has x-y coordinates determined by the position of the laser beam and a z coordinate determined by the height of the point on the helical surface. Any point within the cylindrical image volume can be computer-addressed to appropriately synchronize the laser beam, the Acousto-Optic (AO) Scanner, and the phase of the helix. Using a novel Acousto-Optic (AO) Random-Access Scanner, up to 40,000 laser-generated voxels refreshed at 20 Hz per color are projected onto the reflective surface of the rotating helix. (This is about 10 times more than the current state of the art.) The higher resolution allows improved color images, updated in real-time, for group viewing with the naked eye.

AN (1) AD-B203 938/XAG
CA (5) ASTRO TERRA CORP SAN DIEGO CA
TI (6) Three-Dimensional Volumetric Display.
DN (9) Final rept. 24 Mar-24 Sep 95
AU (10) Korevaar, Eric
Kim, Isaac I.
Hakakha, Harel
Moursund, Carter
RD (11) 28 Sep 1995
PG (12) 27 Pages
CT (15) DASG60-95-C-0032
RN (18) XA-USASSDC
RC (20) Unclassified report
AL (22) Distribution: Further dissemination only as directed by U.S. Army Space and Strategic Defense Command, P.O. Box 1500, Huntsville, AL 35807-3801, 13 Oct 95, or higher DoD authority., This document contains export-controlled technical data.
DE (23) *DISPLAY SYSTEMS, *ACOUSTOOPTICS
HIGH POWER, LASER PUMPING, MIRRORS, MECHANICAL PROPERTIES, FLUORESCENCE, BATTLEFIELDS, EXCITATION, RED(COLOR), AIR TRAFFIC CONTROL SYSTEMS, THREE DIMENSIONAL, BRIGHTNESS, IMAGES, TUNING, TACTICAL DATA SYSTEMS, RUBIDIUM, OMNIDIRECTIONAL, METAL VAPORS, SCANNERS
ID (25) *VOLUMETRIC DISPLAYS, EXPORT CONTROL, BATTLE MANAGEMENT

AN (1) AD-B207 391/XAG
CA (5) STANFORD UNIV CA DEPT OF ELECTRICAL ENGINEERING
TI (6) Non-Moving Imaging Medium for 3-D Volumetric Display.
DN (9) Final rept. for period ending Dec 93
AU (10) Hesselink, L.
Downing, E.
RD (11) Jul 1995
PG (12) 18 Pages
CT (15) N66001-92-D-0092
RN (18) NRAD-TD-2833
XB-NRAD
RC (20) Unclassified report
NO (21) Prepared in cooperation with San Diego State University Foundation, CA.
AL (22) Distribution: Further dissemination only as directed by Commanding Officer, Naval Command, Control and Ocean Surveillance Center, RDT&E Div., San Diego, CA 92152-5001, Jul 95 or higher DoD authority., Availability: Document partially illegible., This document contains export-controlled technical data.
DE (23) *INFRARED LASERS, *COMPUTER GRAPHICS
ALGORITHMS, YAG LASERS, IMAGE PROCESSING, FLUORESCENCE, TUNABLE LASERS, LASER BEAMS, THREE DIMENSIONAL, INFRARED IMAGES, STATIONARY, COLOR DISPLAYS, DATA DISPLAYS, RESEARCH MANAGEMENT, INFRARED SCANNING, NEODYMIUM LASERS, LASER TRACKING, OPTICAL GLASS
ID (25) EXPORT CONTROL

AN (1) AD-B198 183/XAG
CA (5) ACT RESEARCH CORP CAMBRIDGE MA
TI (6) Volumetric Image Display. Multi-Dimensional Visualization of Data to Identify Seismic Events or for Other Multi-Dimensional Problems.
DN (9) Final rept. 1 Sep 94-28 Feb 95
AU (10) Tsao, Che-Chih
RD (11) 29 Mar 1995
PG (12) 66 Pages
CT (15) DAAH01-94-C-R227, ARPA ORDER-5916
RN (18) XT-ARPA
RC (20) Unclassified report
AL (22) Distribution authorized to U.S. Gov't. agencies only; Test and Evaluation; 29 Mar 95. Other requests shall be referred to Director, ARPA, Attn: Tech Info., 3701 No. Fairfax Drive, Arlington, VA 22203-1714.

DE (23) *IMAGE PROCESSING, *SCREENS(DISPLAYS), *IMAGE PROJECTORS
MIRRORS, COMMERCE, MARKETING, COMPUTER PROGRAMMING, OPTICAL IMAGES, DISPLAY SYSTEMS, THREE DIMENSIONAL, SEISMIC DATA, LIQUID CRYSTAL DISPLAY SYSTEMS, PHOTODETECTORS, VOLUMETRIC ANALYSIS, OPTICAL LENSES, FERROELECTRIC CRYSTALS, LIGHT EMITTING DIODES, SEISMIC ARRAYS
ID (25) VID(VOLUMETRIC IMAGE DISPLAY), C++ PROGRAMMING LANGUAGE, MOVING SCREEN PROJECTION

AN (1) AD-A264 825/XAG
CA (5) NAVAL COMMAND CONTROL AND OCEAN SURVEILLANCE CENTER RDT AND E DIV SAN DIEGO CA
TI (6) Laser Based 3D Volumetric Display System.
DN (9) Professional paper
AU (10) Soltan, Parviz
Trias, John
Robinson, Waldo
Dahlke, Weldon
RD (11) Mar 1993
PG (12) 18 Pages
RN (18) XB-NCCOSC/RDT/E
RC (20) Unclassified report
DE (23) *COLOR DISPLAYS, *LASER APPLICATIONS
THREE DIMENSIONAL, IMAGES, QUALITY, COMPUTERS, IMAGE PROCESSING, SHIPBOARD
ID (25) WUDN303151, Multiplanar displays, Volumetric displays, Virtual images
AB (27) In the past several years, the Display Systems Branch, Naval Ocean Systems Center (NOSC), has been involved in the development of laser based display systems with the goal of upgrading the image quality of shipboard displays. In the paper we report work on: (1) developing laser generated 3D volumetric images on a rotating double helix, (where the 3D displays are computer controlled for group viewing with the naked eye), and (2) system feasibility results along with the first and second generation component parameters.

AN (1) AD-A258 995/XAG
CA (5) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF ENGINEERING
TI (6) A User Interface to a True 3-D Display Device.
DN (9) Master's thesis
AU (10) Hobbs, Bruce A.
RD (11) Dec 1992
PG (12) 74 Pages
RS (14) AFIT/GCE/ENG/92D-06
RN (18) XC-AFIT
RC (20) Unclassified report
DE (23) *MAN COMPUTER INTERFACE, *STEREOSCOPIC DISPLAY SYSTEMS, *IMAGE PROCESSING
COMPUTERS, DISKS, DISPLAY SYSTEMS, GRAPHICS, HOST COMPUTERS, IMAGES, INTERACTIVE GRAPHICS, LASERS, MENU, SURFACES, THESES, THREE DIMENSIONAL, VOLUME, WINDOWS
ID (25) User interface
AB (27) This thesis describes an interactive interface to a true three dimensional, real-dm dynamic graphic display, the TI Omniview. The system generates true 3-D images of volumetric data and objects. The TI Omniview is a cylindrical volumetric laser display that uses a rotating double-helix translucent disk to fill the display cylinder. Voxels are illuminated on the 2-D surface. The rotational speed of the disk allows the viewer to fuse the 2-D images into a true 3-D image. The interface provides the user with a quick and flexible means of manipulating the image generated, the sub-volume displayed, and the resulting 3-D image. The interface provides the user with the flexibility and convenience that a window, icon, mouse, and pointer graphical user interface provides to users of 2-D displays. Limitations of the device, however, do not allow the use of icons and pointers in the Omniview display. Instead a combination of voice commands, a joystick, and a 2-D menu system running on a host computer is used to provide the interface.

This interface allows the user to select objects and scenes, but does not allow manipulation, such as rotation or placement, of individual objects.... Three dimensional display systems, Interactive graphics, Man computer interface, 3-D Manipulation.

AN (1) AD-B161 559/XAG
CA (5) THOMAS (MAURICE V) DANVILLE CA
TI (6) Three-Dimensional Volumetric Laser Display Workstation.
DN (9) Final rept. 1 May-31 Oct 91
AU (10) Thomas, Maurice V.
RD (11) Feb 1992
PG (12) 57 Pages
CT (15) F08630-91-C-0036
PJ (16) 3005
TN (17) 11
RN (18) WL*-TR-92-7004
XF-WL*
RC (20) Unclassified report
AL (22) Distribution authorized to U.S. Gov't. agencies only; Premature Dissemination; 3 Jan 92. Other requests shall be referred to WL/MNAA. Eglin AFB, FL 32542-5434.
DE (23) ACOUSTOOPTICS, ANGLES, COLORS, DISPLAY SYSTEMS, EYE, FEASIBILITY STUDIES, HIGH RESOLUTION, MODULATORS, MULTICHANNEL, OPACITY, SPATIAL DISTRIBUTION
ID (25) PE65502F, WUWL30051100, *Data displays, *Three dimensional, *Work stations, Laser displays

AN (1) AD-B159 912/XAG
CA (5) PHYSICAL SCIENCES INC ANDOVER MA
TI (6) A High-Speed Laser Scanner for the NOSC 3-D Volumetric Display.
DN (9) Final rept. for period ending Apr 91.
RD (11) May 1991
PG (12) 27 Pages
CT (15) N66001-91-C-7013
RN (18) NOSC-TD-2122
XN-NOSC
RC (20) Unclassified report
AL (22) Distribution authorized to U.S. Gov't. agencies only; Specific Authority; Proprietary Info.; May 91. Other requests shall be referred to Commander, Naval Ocean Systems Center, San Diego, CA 92152-5000.
DE (23) ADDRESSING, COLORS, CONFIGURATIONS, DISPLAY SYSTEMS, FREQUENCY, LASERS, OPTICAL PROPERTIES, RANDOM ACCESS COMPUTER STORAGE, SCANNERS, SCANNING, VELOCITY, VISIBILITY
ID (25) PE65803N, WUDN307497, *Volumetric displays, *Laser beams, Voxels, Multimedia reports, Naval documents

AN (1) AD-A191 078/XAG
CA (5) BOLT BERANEK AND NEWMAN INC CAMBRIDGE MA
TI (6) Volumetric 3-D Displays and Spatial Perception.
DN (9) Technical rept.
AU (10) Getty, David J.
Huggins, A. W.
RD (11) 1986
PG (12) 26 Pages
RS (14) BBN-TR-5582
CT (15) N00014-80-C-0750
PJ (16) RR04209
TN (17) RR0420901
RC (20) Unclassified report
NO (21) Pub. in Statistical Image Processing and Graphics, p321-343 1986.
DE (23) *VISUAL PERCEPTION, *COMPUTER GRAPHICS
ACCURACY, COMPUTER APPLICATIONS, DISPLAY SYSTEMS, IMAGE PROCESSING, IMAGES, OPTICAL IMAGES, REPRINTS, SPACE PERCEPTION, SPATIAL

DISTRIBUTION, THREE DIMENSIONAL, VOLUME
ID (25) PE61153N, WUNR196166
AB (27) We perceive and comprehend a visual world of three spatial dimensions. However, current computer-generated graphical displays generally fail to utilize the full potential of visual perception in that they create and present only flat 2-D images. Methods are described for extending computer-generated displays to provide three-dimensional images, and focus on the recent development of a practical, true volumetric display. The results are summarized for several perceptual experiments, conducted with this volumetric display, designed to further our understanding of the perception of orientation and direction in a displayed three-dimensional volume. The accuracy of perceived orientation and direction is an important issue in considering possible applications for 3-D displays. Keywords: Reprints; 3-Display; Depth perception; Spatial perception; Orientation; Image processing.

AN (1) AD-B084 452/XAG
CA (5) NAVAL OCEAN SYSTEMS CENTER SAN DIEGO CA
TI (6) Stereoscopic and Volumetric 3-D Displays: Survey of Technology.
DN (9) Final rept. Aug 82-Mar 83
AU (10) Phillips,T. E.
RD (11) Jun 1984
PG (12) 71 Pages
RS (14) NOSC/TR-946
PJ (16) F21242, F21242
TN (17) SF21242601, SF21242001
RC (20) Unclassified report
AL (22) Distribution limited to U.S. Gov't. agencies only; Operational or Administrative Purposes; Jun 84. Other requests must be referred to NOSC, San Diego, CA 92152.
DE (23) *Stereoscopic display systems, *Image processing, *Three dimensional Command and control systems, Holography, Computer applications, Real time, State of the art, Depth, Visual perception, Human factors engineering
ID (25) *Volumetric display systems, Lenticular display systems, PE62721N

AN (1) AD-A140 640/XAG
CA (5) BOLT BERANEK AND NEWMAN INC CAMBRIDGE MA
TI (6) Display-Control Compatibility in 3-D Displays.
DN (9) Final rept. 1 Jul 80-31 Dec 83
AU (10) Huggins,A. W. F.
Getty,D. J.
RD (11) 29 Feb 1984
PG (12) 29 Pages
RS (14) BBN-5584
CT (15) N00014-80-C-0750
PJ (16) RR04209
TN (17) RR0420901
RC (20) Unclassified report
DE (23) *Visual perception, *Performance(Human), *Human factors engineering, *Man machine systems, *Control systems, *Display systems, *Three dimensional
Compatibility, Reaction time, Decision making, Orientation(Direction), Depth, Trajectories, Tracking, Observers, Cathode ray tube screens, Image motion compensation, Axes, Operators(Personnel)
ID (25) Space graph, PE61153N, WUNR196166
AB (27) This research program explored human perceptual performance as influenced by display-control compatibility with a volumetric 3-D display technique. The work was organized into three phases. In the first, we studied how the speed and accuracy of the operator's decisions about the orientation of a displayed object (a cube) was affected as this orientation was varied relative to that of a fixed control (a cubical response box). In the second, we studied how accurately the observer can perceive and project a trajectory presented within the display, as a function of the trajectory's orientation. In

the third phase, we used a real-time control task to measure directly the relative utility of the three dimensions of the display. (Author)

AN (1) AD-A125 806/XAG
CA (5) BOLT BERANEK AND NEWMAN INC CAMBRIDGE MA
TI (6) Display-Control Compatibility in 3-D Displays. 2: Effects of Cue Symmetry.
DN (9) Technical rept.
AU (10) Huggins,A. W. F.
Getty,David J.
RD (11) 15 Nov 1982
PG (12) 67 Pages
RS (14) BBN-5101
CT (15) N00014-80-C-0750
PJ (16) RR04209
TN (17) RR0420901
RC (20) Unclassified report
NO (21) See also AD-A109 491.
DE (23) *Display systems, *Three dimensional, *Orientation(Direction), *Man computer interface
Performance(Human), Performance tests, Decision making, Control systems, Axes, Rotation, Mapping, Mirrors, Response, Compatibility, Accuracy, Spatial distribution, Mental ability, Reaction time, Volume
ID (25) SpaceGraph, PE61153N, WUNR196166
AB (27) This report describes the second set of four experiments in a series of studies on display-control compatibility issues in a true volumetric display called SpaceGraph. As in the initial set of experiments, we measured the speed and accuracy of simple control decisions when the displayed object was presented in orientations rotated away from congruence with the control orientation. Reaction times were measured for identifying the marked face of a static cube, presented with SpaceGraph, as a function of how much the cube image was rotated away from congruence with fixed physical cube on which the observer responded, using orientation cues with various symmetries.

AN (1) AD-A109 491/XAG
CA (5) BOLT BERANEK AND NEWMAN INC CAMBRIDGE MA
TI (6) Display-Control Compatibility in 3-D Displays. 1: Effects of Orientation.
DN (9) Technical rept.
AU (10) Huggins, A. W. F.
Getty, David J.
RD (11) 15 Nov 1981
PG (12) 79 Pages
RS (14) BBN-4724
CT (15) N00014-80-C-0750
RC (20) Unclassified report
DE (23) *DISPLAY SYSTEMS, *THREE DIMENSIONAL, *ORIENTATION(DIRECTION), *MAN COMPUTER INTERFACE
PERFORMANCE(HUMAN), PERFORMANCE TESTS, DECISION MAKING, CONTROL SYSTEMS, AXES, ROTATION, MAPPING, SPATIAL DISTRIBUTION, MENTAL ABILITY, REACTION TIME
ID (25) WUNR196166
AB (27) The recent development of true volumetric displays, such as SpaceGraph, has raised questions about display-control relationships that cannot be answered from earlier work with 2-D displays. We measured the speed and accuracy of simple control decisions when the displayed object was presented in orientations rotated away from congruence with the control orientation. Reaction times were measured for identifying the marked face of a static cube, presented with SpaceGraph, as a function of how much the cube image was rotated away from congruence with fixed physical cube on which the observer responded, and which dimension of the display corresponding to the rotation axis. The following results were obtained: The fastest and most accurate identifications occurred when there was a simple direct spatial mapping between the display and

the control for all orientations presented. Decision times made with this strategy were relatively unaffected by orientation; Marked display-control incompatibility was found under some specific conditions; and The shape of the decision time functions suggest that decision strategies involved both propositioned coding and mental rotation. (Author)

AN (1) AD-A347 740/XAG
CA (5) ARMY RESEARCH LAB ABERDEEN PROVING GROUND MD HUMAN RESEARCH AND ENGINEERINGDIRECTORATE
TI (6) A Comparison of Various Types of Head-Related Transfer Functions for 3-D sound in the Virtual Environment.
DN (9) Final rept.
AU (10) Savick, Douglas S.
RD (11) May 1998
PG (12) 24 Pages
RS (14) ARL-TR-1605
PJ (16) 1L162716AH70
RN (18) XA-ARL/HRED
RC (20) Unclassified report
DE (23) *ARMY TRAINING, *VIRTUAL REALITY, *AUDITORY SIGNALS, *AUDITORY PERCEPTION
COMPUTERIZED SIMULATION, ACOUSTIC FILTERS, DIGITAL FILTERS, HEAD UP DISPLAYS, PSYCHOACOUSTICS, AUDITORY ACUITY, EARPHONES, SOUND GENERATORS
ID (25) HRTF(HEAD RELATED TRANSFER FUNCTIONS), PE62716A, ASH70
AB (27) Simulation using virtual reality (VR) is becoming an effective tool for the Army in training soldiers to do their required tasks. In VR, the human operator can interact with a wide variety of computer generated worlds developed from real or imaginary scenarios or both. The training that a soldier receives by simulation is usually cost effective to the Army and in a number of cases is safer for the individual than training in the real environment. Three dimensional (3-D) sound in the virtual environment (VE) provides a more realistic simulation of acoustic environments compared to diotic (mono) or dichotic (stereo) sound presentation. The major benefit of using 3-D sound is that an individual can determine the sound source direction. When sounds that are perceived to have direction and sights that represent virtual objects that produce the sounds are provided through a head mounted display, a person can monitor and identify sources of information from all possible locations. The purpose of this study was to determine if 3-D sound generated by a 3-D sound system could enhance the realism or fidelity of the VE. The main objective of the study was to determine if an individual could distinguish the direction of a sound source within a reasonable degree of accuracy. Three dimensional sound is produced by using a mathematical representation of the filtering characteristics of the pinnae provided through head related transfer functions (HRTFs). The HRTFs can be developed by recording a generated broadband sound using a probe microphone in the ear canal and subsequently dividing the Fourier transform of the recorded sound by that of the generated sound. When digital filtering techniques are used, HRTFs can be applied to sounds through headphones. When an arbitrary sound is filtered with HRTF based filters, the sound should appear to come from specified virtual locations outside the earphones.

AN (1) AD-B206 205/XAG
CA (5) CRYSTAL RIVER ENGINEERING INC GROVELAND CA
TI (6) Spatial Acoustic Sound for Virtual Environment Applications. Phase 1.
DN (9) Final rept.
AU (10) Foster, Scott
Schneider, Tony
RD (11) 19 Dec 1995
PG (12) 32 Pages
CT (15) N00014-95-C-2123
RN (18) XB-NRL
RC (20) Unclassified report

AL (22) Distribution authorized to U.S. Gov't. agencies only; Proprietary Info.; 23 Jan 96. Other requests shall be referred to Naval Research Lab., 4555 Overlook Avenue, SW, Washington, DC 20375-5326.
DE (23) *VIRTUAL REALITY, *SOUND GENERATORS
ALGORITHMS, COMPUTERIZED SIMULATION, IMAGE PROCESSING, SPATIAL DISTRIBUTION, DATA MANAGEMENT, COMPUTER COMMUNICATIONS, REAL TIME, STATE OF THE ART, DISPLAY SYSTEMS, THREE DIMENSIONAL, TELECOMMUNICATIONS, INTERACTIVE GRAPHICS, SOUND WAVES, REVERBERATION, ACOUSTIC DATA, ACOUSTIC FIELDS, CONFERENCING(COMMUNICATIONS) , AUDITORY SIGNALS, AUDIO TONES, CUES(STIMULI), OBJECT ORIENTED PROGRAMMING
ID (25) API(APPLICATION PROGRAM INTERFACE), BINAURAL PROCESSING, CLIENT SERVER TECHNOLOGY

AN (1) AD-A299 995/XAG
CA (5) NAVAL COMMAND CONTROL AND OCEAN SURVEILLANCE CENTER RDT AND E DIV SAN DIEGO CA
TI (6) Task-Oriented Quantitative Testing for Synthesized 3-D Auditory Displays
DN (9) Professional paper
AU (10) Julig, Louise F.
Kaiwi, Jerry L.
RD (11) May 1995
PG (12) 3 Pages
RN (18) XB-NCCOSC/RDT/E
RC (20) Unclassified report
AL (22) Availability: Pub. in Proceedings of the International Conference (2nd) on Auditiory Display, p273, May 95. Available only to DTIC users. No copies furnished by NTIS.
DE (23) *DISPLAY SYSTEMS, *MAN MACHINE SYSTEMS, *AUDITORY PERCEPTION
SIGNAL PROCESSING, REPRINTS, THREE DIMENSIONAL, ACOUSTIC SIGNALS, MAN COMPUTER INTERFACE, ACOUSTIC FIELDS, HEARING, AUDIO FREQUENCY, AUDITORY SIGNALS, EARPHONES, CUES(STIMULI), LOUDNESS, PITCH DISCRIMINATION, SONAR PERSONNEL
ID (25) PE62233N, WUDN309119
AB (27) Current human machine interfaces in Navy systems which incorporate headphone listening fail to take full advantage of human binaural sensory processing capabilities. These interfaces can be improved by providing the capability to present multiple spatialized audio channels over headphones using technology which is available today. Before these changes are considered, quantitative testing must take place which addresses the task to be performed, and the impact the spatialization will have on the task. This poster will describe a testing system for quantifying the effects of 3-D audio spatialization on a detection and classification problem similar in important ways to a sonar operator's task.

AN (1) AD-A259 041/XAG
CA (5) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF ENGINEERING
TI (6) Enhancement of Audio Localization Cue Synthesis by Adding Environmental and Visual Cues.
DN (9) Master's thesis
AU (10) Scarborough, Eric L.
RD (11) Dec 1992
PG (12) 129 Pages
RS (14) AFIT/GE/ENG/92D-34
RN (18) XC-AL/WPAFB
RC (20) Unclassified report
DE (23) *ACOUSTIC EQUIPMENT, *AUDITORY PERCEPTION, *COMPUTER GRAPHICS, *EARPHONES, *HEAD(ANATOMY)
ACOUSTIC REFLECTION, DEMONSTRATIONS, DIRECTIONAL, IMAGES, REAL TIME, SIGNALS, SIMULATION, SOUND, THREE DIMENSIONAL, CUES(STIMULI), THESES
ID (25) DIRAD(Directional Audio Display)
AB (27) An audio localization cue synthesizer, the DIRectional Audio Display (DIRAD) was used to simulate auditory distance, room reflections, and

to provide spatial audio for computer graphics images. The DIRAD processes input audio signals to generate spatially located sounds for headphone listening. The DIRAD can position audio sources around the head and these sounds are stable with respect to the listener's head position. An interactive, real-time simulation of auditory distance and room reflections was accomplished using the DIRAD in combination with a Silicon Graphics audio processor board installed in a Personal Iris 4D/35. Several demonstrations of auditory distance and the effects of early reflections are detailed, including a simulation of a direct sound source and three reflections that employed two DIRAD systems. Stored sound files were used to accompany three dimensional graphics images that were displayed on both a Silicon Graphics CRT and a three dimensional optical display device. The use of the 4D/35 audio processor board proved to be an effective means of preprocessing audio for the DIRAD for these simulations. The combination of AFIT's Silicon Graphics workstations and the DIRAD proved to be a practical solution to the problem of combining virtual visual and audio cues.... Auditory localization, Auditory perception, Virtual reality, 3-D Audio, Acoustic reflection, Sound equipment.

AN (1) AD-A260 934/XAG
CA (5) SOUTHEASTERN CENTER FOR ELECTRICAL ENGINEERING EDUCATION INC ST CLOUD FL
TI (6) Design, Fabrication, and Testing of a Three-Dimensional Acoustic Orientation Instrument (3-D AOI)--Drawings, Engineering, and Associated Lists(Conceptual and Development Design).
DN (9) Final rept. 1 May 89-15 Apr 91
AU (10) Fulgham, Dan D.
Gabelmann, Jeffrey
RD (11) Dec 1992
PG (12) 133 Pages
RS (14) SWRI-PN-12-3384
CT (15) F33615-87-D-0609
PJ (16) 7930
TN (17) 20
RN (18) AL-TR-1992-0154
XC-AL/BROOKS
RC (20) Unclassified report
DE (23) *AUDITORY SIGNALS, *FLIGHT INSTRUMENTS, *AIRSPEED ACOUSTICS, COMPUTERS, EARPHONES, FLIGHT, INSTRUMENTATION, SIGNAL PROCESSING, THREE DIMENSIONAL, DATA PROCESSING EQUIPMENT, MAN COMPUTER INTERFACE, MIXERS(ELECTRONICS), WHITE NOISE
ID (25) PE62202F, WUAL79302002, WU02
AB (27) Subcontractor (Southwest Research Institute) provides a description of the hardware assembled and software created to develop the 3-D AOI. A Macintosh llx computer is the heart of the system, acting as a general controller and processor of data flowing from the Flight Information Package to the Audio Localization Cue Synthesizer, audio mixer, headphones, and data recording equipment. A National Instruments NB-DSP2300 digital signal processing board and NB-A2100 audio 1/0 board generate the audio signals, and National instruments LabView software is used to control the auditory display. The majority of this report is a description of the 18 LabView software modules created to control the 3-D AOI display.... Acoustic orientation, Flight instrumentation, Auditory localization, Aural displays.

AN (1) AD-A314 933/XAG
CA (5) ARMSTRONG LAB WRIGHT-PATTERSON AFB OH CREW SYSTEMS DIRECTORATE
TI (6) Hand Gesture Recognition Using Neural Networks.
DN (9) Final rept. Nov 93-Sep 95
AU (10) Morton, Paul R.
Fix, Edward L.
Calhoun, Gloria L.
RD (11) May 1996

PG (12) 36 Pages
RS (14) AL/CF-SR-1996-0005
PJ (16) 7184
TN (17) 14
RN (18) XC-AL/CF
RC (20) Unclassified report
DE (23) *NEURAL NETS, *MOTION, *RECOGNITION
CONTROL, AIR FORCE, NETWORKS, MAPS, MANUAL OPERATION, STATICS, HANDS, SELF ORGANIZING SYSTEMS, ALPHABETS, RETRAINING
ID (25) *HAND GESTURES, PE62202F, WUAL7184146H
AB (27) Gestural interfaces have the potential of enhancing control operations in numerous applications. For Air Force systems, machine-recognition of whole-hand gestures may be useful as an alternative controller, especially when conventional controls are less accessible. The objective of this effort was to explore the utility of a neural network-based approach to the recognition of whole-hand gestures. Using a fiber-optic instrumented glove, gesture data were collected for a set of static gestures drawn from the manual alphabet used by the deaf. Two types of neural networks (multilayer perceptron and Kohonen self-organizing feature map) were explored. Both showed promise, but the perceptron model was quicker to implement and classification is inherent in the model. The high gesture recognition rates and quick network retraining times found in the present study suggest that a neural network approach to gesture recognition be further evaluated.

AN (1) AD-A367 429/XAG
CA (5) NATO RESEARCH AND TECHNOLOGY ORGANIZATION NEUILLY-SUR-SEINE (FRANCE)
TI (6) Alternative Control Technologies (Technologies de Controle non Conventionnelles)
DN (9) Technical rept.
AU (10) Hudgins, Bernard
Leger, Alain
Dauchy, Pierre
Pastor, Dominique
Pongratz, Hans
RD (11) Dec 1998
PG (12) 147 Pages
RS (14) RTO-TR-7, AC/323(HFM)TP/3
RN (18) X5-X5
RC (20) Unclassified report
DE (23) *COCKPITS, *HUMAN FACTORS ENGINEERING, *ARTIFICIAL INTELLIGENCE
COMPUTERIZED SIMULATION, NATO, FIGHTER AIRCRAFT, INTEGRATED SYSTEMS, NEURAL NETS, ADAPTIVE CONTROL SYSTEMS, STATE OF THE ART, FRANCE, SPEECH RECOGNITION, EYE, MAN MACHINE SYSTEMS, MAN COMPUTER INTERFACE, HEAD(ANATOMY), REMOTELY PILOTED VEHICLES, AUTOMATIC PILOTS, VOICE COMMUNICATIONS, EYE MOVEMENTS
ID (25) FOREIGN REPORTS, NATO FURNISHED
AB (27) In January 1996, the Working Group 25 of the former AGARD Aerospace Medical Panel began to evaluate the potential of alternative (new and emerging) control technologies for future aerospace systems. The present report summarizes the findings of this group. Through different chapters, the various human factors issues related to the introduction of alternative control technologies into military cockpits are reviewed, in conjunction with more technical considerations of the state of the art of the enabling technologies. Cockpit integration issues are emphasized in regard to both human factors and engineering constraints. Several specific applications of these new technologies in the aerospace environment are considered. Challenges for further developments are identified and recommendations issued. Globally, based upon operational considerations and currently recognized limitations of the HOTAS concept, the conclusion is that Alternative Control Technology should now be progressively introduced into the cockpit, as a function of degree of maturity of the various techniques.

AN (1) AD-A207 748/XAG
CA (5) SCHOOL OF AEROSPACE MEDICINE BROOKS AFB TX
TI (6) Towards a Physiologically Based HUD (Head-Up Display) Symbology.
DN (9) Final rept. Jul 87-Jun 88
AU (10) Previc, Fred H.
RD (11) Jan 1989
PG (12) 22 Pages
RS (14) USAFSAM-TR-88-25
PJ (16) 7930
TN (17) 20
RC (20) Unclassified report
DE (23) *ATTITUDE CONTROL SYSTEMS, *HEAD UP DISPLAYS, *SYMBOLS, *HUMAN FACTORS ENGINEERING
AIRCRAFT, ATTENTION, ATTITUDE INDICATORS, DISPLAY SYSTEMS, FLIGHT CONTROL SYSTEMS, HORIZON, HUMANS, OPTICAL IMAGES, PHYSIOLOGY, PILOTS, ROLL, SIMULATION, STABILITY, STRUCTURES, TERRAIN, THREE DIMENSIONAL, VISION, VISUAL AIDS, VISUAL PERCEPTION, VISUAL SIGNALS, MAN MACHINE SYSTEMS
ID (25) PE62202F, WUUSAFSAM79302001
AB (27) New concepts in HUD symbology, based on an understanding of the physiological mechanisms and ecological origins of the human visual system are described which may enable future HUD displays to serve as primary flight directors in addition to their current roles. The four key elements of this new symbology are: a) prioritization of space according to the three-dimensional structure of visual attention, b) an attitude display in the form of a global percept; c) effective preattentive attitude cueing based on an ecologically valid simulation of the visual terrain during flight ; and d) visual reference framing which depicts the roll of the aircraft relative to a stable horizon. Prototypes which illustrate the 'physiological HUD' concept are presented. The specific advantage of the proposed symbology may be to allow the pilot to maintain effective attitude control while directing his attention towards the out-the-window environment. Keywords: Head up displays, visual perception, Visual displays, Pilots. (aw)

AN (1) AD-A204 394/XAG
CA (5) NAVAL AEROSPACE MEDICAL RESEARCH LAB PENSACOLA FL
TI (6) Further Progress in Development of a Performance-Based Test of Gaze Control Capability.
DN (9) Interim rept. Oct 83-Mar 88
AU (10) Hixson, W. C.
Guedr, Fred E., Jr.
Lentz, J. M.
RD (11) Sep 1988
PG (12) 23 Pages
RS (14) NAMRL-1342
PJ (16) M0096
TN (17) M0096001
RN (18) XB-NAMRL
RC (20) Unclassified report
DE (23) *LINE OF SIGHT, *PERFORMANCE TESTS, *VISION
TEST AND EVALUATION, CONTROL, ANGLES, MARINE CORPS, PERFORMANCE(HUMAN), PILOTS, ORIENTATION(DIRECTION), ARRAYS, POPULATION, TIME, VARIATIONS, FLIGHT, VISUAL PERCEPTION, EXPOSURE(PHYSIOLOGY), RANGE(EXTREMES), NUMBERS, SEMIAUTOMATIC, SCORING, BIOMEDICINE, VESTIBULAR APPARATUS
ID (25) *GAZE, PE63706N, WUDN577604, HEAD EYE COORDINATION
AB (27) A performance-based test of gaze capability has been developed using low-cost light-emitting-diode (LED) displays operated under the semi-automated control of a desk top micro-computer. The test is based on the ability of an individual to rapidly shift his gaze over a relatively large angle and precisely identify digits presented in a numeric array for brief, time-varied exposure times. The new test, involving four widely-spaced displays, allows the derivation of performance scores for gaze shifts involving head movements made in the left, right, up, and down directions. The results of three experiments involving Navy and Marine Corps flight candidates as subjects, support

the original report findings relative to the heavy influence of exposure time on performance, and most importantly, the wide range of performance capabilities reflected within the study population. This latter point has the potential for operational significance in that the test should distinguish pilots with exceptional gaze capabilities from those with relatively poor gaze performance. Keywords: Vestibular apparatus, Head/eye coordination, Biomedical tests. (aw)

AN (1) AD-A039 999/XAG
CA (5) AEROSPACE MEDICAL RESEARCH LAB WRIGHT-PATTERSON AFB OHIO
TI (6) A Visually-Coupled Airborne Systems Simulator (VCASS) - An Approach to Visual Simulation.
DN (9) Conference paper
AU (10) Kocian,Dean F.
RD (11) 1977
PG (12) 10 Pages
RS (14) AMRL-TR-77-31
PJ (16) 7184
TN (17) 20
RC (20) Unclassified report
NO (21) Presented at the IMAGE Conference, Phoenix, Ariz., 17-18 May 77.
DE (23) *Display systems, *Flight simulators
Man machine systems, Flight training, Stereoscopic display systems, Pilots, Space perception, Head up displays, Helmet mounted displays, Visual perception, Coupling(Interaction), Flight crews
ID (25) WUAMRL71842001, PE62202F
AB (27) This paper describes a new approach to solving the visual presentation problems of aircraft simulators by using visually coupled systems (VCS). For many years it has been the mission of this laboratory to optimize the visual interface of crew members to advanced weapon systems. This mission has been primarily pursued in two areas: (1) the establishment of control/display engineering criteria; and (2) the prototyping of advanced concepts for control and display interface. An important part of fulfilling this mission has been the development of VCS components which includes head position sensing systems or helmet mounted sights (HMS), eye position sensing systems (EPS) and helmet mounted displays (HMD). The author believes that the unique capabilities of a visually-coupled system (VCS -combination of a helmet-mounted sight and helmet-mounted display) can meet the simulation requirements as well as improve upon existing ground based simulation techniques.

AN (1) AD-A387 023/XAG
CA (5) SYTRONICS INC DAYTON OH
TI (6) Integrated, Hands-Free Control Suites for Maintenance Wearable Computers-VHIC
DN (9) Final rept.
AU (10) Valiton, Jeff
Grigsby, Scott
Choate, Tim
RD (11) Jan 2001
PG (12) 82 Pages
RS (14) SYT-798-001
CT (15) F33615-00-M-6053
RN (18) XC-AFRL
RC (20) Unclassified report
NO (21) Produced in cooperation with the Univ. of Dayton Research Institute, Dayton, OH.
DE (23) *COMPUTERS, *INFORMATION RETRIEVAL, *SPEECH RECOGNITION, *MAN COMPUTER INTERFACE
AIRCRAFT MAINTENANCE, MAINTENANCE PERSONNEL, MAINTENANCE MANAGEMENT, MANPORTABLE EQUIPMENT, MICROPHONES, NATURAL LANGUAGE, HELMET MOUNTED DISPLAYS, MAINTENANCE EQUIPMENT
ID (25) SBIR(SMALL BUSINESS INNOVATION RESEARCH), VHIC(VOICE HEAD INPUT CONTROLLER)

AB (27) Final Report for the Integrated, Hands-Free Control Suites for Maintenance Wearable Computers-VHIC. SYTRONICS and UDRI applied significant experience and familiarity with the warfighter's needs in aircraft maintenance to the problem of having hands-free control of wearable computers so that they may access technical data easily and effectively. This report outlines the development of an operation prototype that is an innovative combination of head-tracking and speech recognition for effective and intuitive interfacing that was used by subject matter experts to evaluate the utility of the system. A simple two-controller approach uses voice for text-and-click entry and head movement, as well as speech, for pointing. A dampered throat microphone filters noise and a simple inertial tracker provides cursor movement.

AN (1) AD-B260 938/XAG
CA (5) RAYTHEON CO STATE COLLEGE PA STATE COLLEGE OPERATIONS
TI (6) Speech Technologies Integration (STI)
DN (9) Final rept. Jun 1998-Jun 2000
AU (10) Stock, Chad
RD (11) Sep 2000
PG (12) 39 Pages
CT (15) F30602-98-C-0188
PJ (16) 1049
TN (17) 02
RN (18) AFRL-IF-RS-TR-2000-138
XC-AFRL-IF-RS
RC (20) Unclassified report
AL (22) Distribution authorized to U.S. Gov't. agencies and their contractors; Critical Technology; Sep 2000. Other requests shall be referred to Air Force Research Lab/IFEC, Rome, NY 13441., This document contains export-controlled technical data.
DE (23) *SPEECH RECOGNITION
ALGORITHMS, SOFTWARE ENGINEERING, TEST BEDS, DISPLAY SYSTEMS, CORRELATION, INTEGRATION, SPEECH REPRESENTATION, GRAPHICAL USER INTERFACE
ID (25) EXPORT CONTROL, AUDIO CORRELATION, SPEAKER IDENTIFICATION, STI(SPEECH TECHNOLOGIES INTEGRATION)PROGRAM, PE35885G, WUAFRL10490208
AB (27) This program developed a speech technology integration testbed. An audio correlation algorithm was delivered to AFRL an demonstrated with speaker and language identification algorithms. Advanced displays, tailored to the operational user were developed to include prototype communications network and echelon displays. Finally, vital tables used in the correlation algorithm were modified to better reflect inputs.

AN (1) AD-A367 318/XAG
CA (5) ARMY AEROMEDICAL RESEARCH LAB FORT RUCKER AL
TI (6) Concept Phase Evaluation of the Microvision, Inc. Aircrew Integrated Helmet System HGU-56P Virtual Retinal Display
DN (9) Final rept.
AU (10) Rash, Clarence E.
Harding, Thomas H.
Martin, John S.
Beasley, Howard H.
RD (11) Aug 1999
PG (12) 27 Pages
RS (14) USAARL-99-18
PJ (16) 30162787A879
RN (18) XA-USAMRMC
RC (20) Unclassified report
DE (23) *VISUAL PERCEPTION, *HELMET MOUNTED DISPLAYS, *DIODE LASERS
TEST AND EVALUATION, SOURCES, OPTICAL PROPERTIES, PROTOTYPES, VERTICAL ORIENTATION, LUMINANCE
ID (25) PE62787A, WUDA336445
AB (27) In support of the RAH-66 Comanche, Microvision Inc., Seattle, Washington, has developed a prototype helmet mounted display based on laser diode sources. This prototype has been evaluated for optical and

visual performance. Tests include: exit pupil size and shape, eye relief, field-of-view, luminance, contrast, contrast transfer function(CTF), modulation transfer function(MTF), and interpupilary distance and vertical adjustments.

AN (1) AD-B247 416/XAG
CA (5) VERIDIAN BROOKS AFB TX
TI (6) Assessment of Aerospace Visual Performance in Three Prototype Holographic Spectacles for Laser Eye Protection
DN (9) Final rept. Sep 96-Apr 98
AU (10) Kang, Robert N.
Ghani, Nadeem
Garcia, Paul V.
Dykes, James R., Jr.
Maier, Dennis A.
RD (11) Jun 1999
PG (12) 20 Pages
CT (15) F41624-97-D-9000
PJ (16) 7757
TN (17) B2
RN (18) AFRL-HE-BR-TR-1999-0178
XC-AFRL-HE-BR
RC (20) Unclassified report
NO (21) Prepared in cooperation with TASC, Inc. San Antonio, TX.
AL (22) Distribution authorized to U.S. Gov't. agencies only; Proprietary Info; Jan 98 Other requests shall be referred to AFRL/HEOA, Brooks AFB, TX 78235-5118
DE (23) *EYE SAFETY, *PROTECTIVE EQUIPMENT
PHYSICAL PROPERTIES, MILITARY STANDARDS, AEROSPACE SYSTEMS, HOLOGRAPHY, COLOR DISPLAYS, VISUAL PERCEPTION, RADIATION PROTECTION, LASER SAFETY, VISUAL ACUITY, COLOR VISION, EYEGLASSES
ID (25) LEP(LASER EYE PROTECTION), SPECTACLES, MPCD(MULTI-PURPOSE COLOR DISPLAY), PE62202F, WUAFRL7757B298

AN (1) AD-B244 180/XAG
CA (5) HONEYWELL TECHNOLOGY CENTER MINNEAPOLISMN
TI (6) Hand-Held and Body-Worn Graphical Display System
DN (9) Final rept. Jun 96-Jun 98
AU (10) Havey, G.
Hanzal, B.
Lewis, S.
RD (11) Apr 1999
PG (12) 81 Pages
RS (14) C-98233
CT (15) DAAK60-96-C-3023
RN (18) ASBCC-TR-99/024L
XA-ASBCC
RC (20) Unclassified report
AL (22) Distribution authorized to U.S. Gov't. agencies and private individuals or enterprises eligible to obtain export-controlled technical data in accordance with DoDD 5230.25, Sep 86. Controlling DoD office is Commander, US Army Soldier and Biological Chemical Command, Soldier Systems Center, Attn: AMSSB-RSS-D(N), Natick, MD 01760-5015., This document contains export-controlled technical data.
DE (23) *ELECTROLUMINESCENCE, *COLOR DISPLAYS, *POCKET COMPUTERS
PROTOTYPES, COMPUTER GRAPHICS, RADIO LINKS, HAND HELD, RADIOTELEPHONES
ID (25) EXPORT CONTROL
AB (27) This report describes work completed on the Hand Held and Body Worn Graphical Display System program. Two novel applications of color miniature active matrix electroluminescent (AMEL) displays were developed, prototyped and delivered to the Army. These novel display system prototypes were used to explore new ways for the soldier to access graphical and image data in the field. The first prototype, called the Body Worn Display, has a wireless RF link of color 640 x 480 VGA data. The RF allows the display to be updated at 30 frames per

second, a data rate high enough for video to be viewed. This first of its kind wireless display design provides the soldier with all the performance of a hard wired display, but in a highly flexible package. Because it is wireless, the display can be easily worn, handled, pocketed and shared. The second prototype, a hand held computer with a see through display represented an alternative to simply using a large, direct view display with a hand held computer. A scope with a color display in the optical path was combined with a hand held computer. The displayed image is superimposed on the real world as viewed through the scope. This capability to view a computer screen overlaid onto the real world allows for some innovative applications such as image capture/comparison and terrain map overlaying.

AN (1) AD-A331 330/XAG
CA (5) OPTRON SYSTEMS INC BEDFORD MA
TI (6) Very-High-Resolution, Large Field-of-View, Wireless Color Helmet-Mounted Display
DN (9) Final rept. 22 Apr-22 Oct 96
RD (11) 12 Nov 1996
PG (12) 17 Pages
CT (15) DAAL01-96-C-0028
RN (18) XA-ARL*
RC (20) Unclassified report
DE (23) *LIQUID CRYSTAL DISPLAY SYSTEMS, *HELMET MOUNTED DISPLAYS, *SILICON ON SAPPHIRE
LINE OF SIGHT, OFF THE SHELF EQUIPMENT, OPTICAL COMMUNICATIONS, HIGH RESOLUTION, HUMAN FACTORS ENGINEERING, COLOR DISPLAYS, VISUAL PERCEPTION, MAN COMPUTER INTERFACE, SHUTTERS(OPTICS), PIXELS, LOW RESOLUTION, STEREOSCOPIC DISPLAY SYSTEMS
AB (27) The main goals of our program can be summarized as follows: (1) To design and build a helmet mounted display with commercially available components in order to demonstrate the proposed dual insertion display concept which will provide a very large field of view (FOV image). (2) To design and layout silicon on sapphire circuits which will be used in the Phase 2 work. (3) To examine the issues associated with the wireless communication of images. The goal of the Phase 2 program is to replace the commercially available low resolution displays of the Phase 1 HMD prototype with ultrathin silicon on sapphire based active matrix addressed liquid crystal displays (AMLCDs). As explained in the following sections of the proposal, the use of ultrathin silicon on sapphire (UTSOS) technology provides some fundamental advantages which gives us the technological edge when competing with other display companies. The final HMD will receive image data via wireless transmission channels. Color will be generated using Textronix color shutters.

AN (1) AD-B248 123/XAG
CA (5) PLANNING SYSTEMS INC MCLEAN VA
TI (6) Application of Advanced 3-D Visualization Techniques to Tactical Decision Aids for Naval Warfare
DN (9) Final rept.
AU (10) Diehl, David W., Jr.
RD (11) Jul 1995
PG (12) 98 Pages
RS (14) PSI-TR-SBIR-1812-0795
CT (15) N00024-94-C-4217
RN (18) XB-NAVSEA
RC (20) Unclassified report
AL (22) Distribution authorized to U.S. Gov't. agencies and their contractors; Specific Authority; Jul 95. Other requests shall be referred to Naval Sea Systems Command, Code 03R5, Arlington, VA 22242-5160.
DE (23) *NAVAL WARFARE, *TACTICAL WARFARE, *DECISION AIDS
DATA BASES, REAL TIME, COST ANALYSIS, INTERACTIONS, PROGRAMMING LANGUAGES, DISPLAY SYSTEMS, THREE DIMENSIONAL, LOW LEVEL, MAN COMPUTER INTERFACE, TOOL KITS, MILITARY CRITICAL TECHNOLOGY

ID (25) TACTICAL DECISION AID
AB (27) In our Phase I SBIR effort, we sought to define the requirements for a 3-D toolkit for tactical decision aids, evaluate current and emerging 3-D tools, establish a toolkit, and develop and evaluate a prototype display to demonstrate the toolkit's utility. Our study of 30 3-D toolkits revealed that tools capable of producing satisfactory TACAIDs on TAC-N platforms entail high licensing costs. We showed that a toolkit developed specifically for ASTO-E would entail substantially lower licensing costs. We developed a core 3-D toolkit and used it to build a prototype active sonar search effectiveness display. Its ability to interactively manipulate challenging data sets on a typical TAC-3 platform without special 3-D graphics acceleration hardware demonstrated the feasibility of using it to build most 3-D SPP displays. A full-scale 3-D toolkit can be developed to provide the TACAID developer with rapid prototyping capabilities, independence from low-level language interaction, portability, and run-time license free distribution of displays.

AN (1) AD-A230 649/XAG
CA (5) NAVAL OCEAN SYSTEMS CENTER SAN DIEGO CA
TI (6) A Head Coupled Sensor Platform for Teleoperated Ground Vehicles
AU (10) McDonnell, John R.
Solorzano, Manuel R.
Martin, Stephen W.
Umeda, Alan Y.
RD (11) Dec 1990
PG (12) 10 Pages
RN (18) XN-USMC
RC (20) Unclassified report
DE (23) COUPLING(INTERACTION), DETECTORS, DISPLAY SYSTEMS, DYNAMICS, ELECTROMECHANICAL DEVICES, FORMULATIONS, GROUND VEHICLES, HEAD UP DISPLAYS, PLATFORMS, PROTOTYPES, REMOTE SYSTEMS, SIMULATION, TELEOPERATORS, TILT, TRAJECTORIES, UNMANNED, VISION
ID (25) Head mounted displays, Telerobotics, TOV(Teleoperated Vehicles), Remote vision, Ground vehicles, Teleoperators, Remote areas/control, Audiovisual aids, Head anatomy motion, Remote detectors, Robotics, Television systems, PE65151M, WUDN308274
AB (27) This paper describes a remote vision system applicable to the teleoperation of unmanned ground vehicles. The features of the remote vision system are presented along with a description of its components: a sensor suite, a head slaved platform, and a head mounted display. An emphasis is placed on the remote platform dynamics. Performance goals are discussed and nominal head trajectories generated for use in a simulation study which was conducted to determine if these goals are achievable. Simulation and experimental results demonstrate that the electromechanical pan and tilt prototype approaches the desired performance goals. An analytical formulation of the pan and tilt dynamics is also given. (EDC)

AN (1) AD-B149 475/XAG
CA (5) CAE ELECTRONICS LTD MONTREAL (QUEBEC)
TI (6) Flight Simulator: Advanced Wide Field-of-View, Helmet-Mounted, Infinity Display System.
DN (9) Final rept. Jun 85-Jun 89
AU (10) Barrette, R.
Dunkley, K.
Kruk, R.
Kurts, D.
Marshall, S.
RD (11) Sep 1990
PG (12) 234 Pages
CT (15) F33615-81-C-0012
PJ (16) 2743
TN (17) 25
RN (18) AFHRL-TR-89-36

XF-AFHRL
RC (20) Unclassified report
AL (22) Distribution authorized to U.S. Gov't. agencies and Private individuals or enterprises eligible to obtain export-controlled technical data in accordance with DoDD 5230.25 Sep 90. Controlling DoD office is AFHRL/PRTS, Brooks AFB, TX 78235-5601.
DE (23) *FLIGHT SIMULATORS, *HELMET MOUNTED DISPLAYS
BLENDING, BUNDLES, COLORS, DETECTORS, DISPLAY SYSTEMS, EYE, FIBER OPTICS, HELMETS, MODELS, NOISE, OPTICAL PROPERTIES, PATTERNS, PROTOTYPES, RATES, SIMULATION, TRACKING, VIDEO SIGNALS, VISION, VISUAL PERCEPTION, WIDE ANGLES, JET FIGHTERS
ID (25) EXPORT CONTROL, Field of View, F-16 aircraft
AB (27) This report details the continuing development of a fiber-optic-coupled, head-and eye-slaved, helmet-mounted display. An advanced prototype model has been developed and installed in conjunction with a multiprocessor-based F-16 flight simulator. The new optical design results in a wider instantaneous field of view and better color rendition. Improvements in custom helmets, use of rate sensors in head-tracking, and better video blending techniques are described. Techniques for substantially reducing fiber-optic bundle pattern noise have been explored. Studies have been conducted to validate and optimize display performance. The development program for a helmet-mounted eye-tracker is described. Requirements for a fully eye-slaved system are addressed. Keywords: Eye tracking, Fiber optics, Helmet-mounted display, Infinity display, Visual simulation. (sdw)

AN (1) AD-A230 316/XAG
CA (5) HARRY G ARMSTRONG AEROSPACE MEDICAL RESEARCH LAB WRIGHT-PATTERSON AFB OH
TI (6) Localization Performance with Synthesized Directional Audio.
DN (9) Interim rept. Jan-Sep 89
AU (10) Agnew, Jeffrey R.
German, Valencia
Calhoun, Gloria L.
Ericson, Mark A.
RD (11) Jul 1990
PG (12) 72 Pages
RS (14) AAMRL-TR-90-025
RN (18) XA-AAMRL
RC (20) Unclassified report
DE (23) ACOUSTIC SIGNALS, ANGLES, AZIMUTH, EARPHONES, ELEVATION, ESTIMATES, HEAD(ANATOMY), MOTION, PROTOTYPES, RESPONSE, STIMULI, TARGETS
ID (25) PE62202F
AB (27) This report summarizes three studies designed to measure and compare the ability of subjects to localize sounds in azimuth, via headphones, generated by two prototype auditory localization cue synthesizers. In the first study, performance differences were found between the two synthesizers in certain areas of the azimuth plane. Additionally, the design of a synthesizer (e.g., resolution and interpolating between head-related transfer functions (HRTFs) can impact the perceived direction of the acoustic signals. Previous research with directional audio suggests that the verdicality of 3-D auditory displays could be optimized if individualized HRTFs are employed to synthesize the virtual sound sources, particularly in elevation. However, data from this experiment suggest that this design requirement can be relaxed, especially if only azimuth information is to be conveyed by the localization synthesizer. In the second study, two response methods for measuring localization performance were evaluated. No performance differences were found when subjects either verbally reported angular estimates or pointed to a circle to indicate the perceived direction of the target stimuli. In the third study, performance was impacted by manipulating the bandwidth of the acoustic signal and head movement. (RH)

AN (1) AD-A222 545/XAG
CA (5) NORTH CAROLINA UNIV AT CHAPEL HILL DEPT OF COMPUTER SCIENCE
TI (6) Tracking a Head-Mounted Display in a Room-Sized Environment with Head-Mounted Cameras
AU (10) Wang, Jih-Fang
Azuma, Ronald
Bishop, Gary
Chi, Vernon
Eyles, John
RD (11) 1990
PG (12) 11 Pages
CT (15) N00014-86-K-0680
RC (20) Unclassified report
DE (23) *HEAD UP DISPLAYS, *CAMERAS
CEILING, DETECTORS, DISPLAY SYSTEMS, ENVIRONMENTS, GRIDS, HELMETS, HOLOGRAPHY, INFRARED BEACONS, LENSES, MOUNTS, ORIENTATION(DIRECTION), PANELS, PHOTODIODES, TRACKING, VOLUME
AB (27) This paper presents our efforts to accurately track a Head Mounted Display (HMD) in a large environment. We review our current benchtop prototype (introduced in (WCF90)), then describe our plans for building the full-scale system. Both systems use an inside-out optical tracking scheme, where lateral-effect photodiodes mounted on the user's helmet view flashing infrared beacons placed in the environment. Church's method uses the measured 2D image positions and the known 3D beacon locations to recover the 3D position and orientation of the helmet in real-time. We discuss the implementation and performance of the benchtop prototype. The full-scale system design includes ceiling panels that hold the infrared beacons and a new sensor arrangement of two photodiodes with holographic lenses. In the full-scale system, the user can walk almost anywhere under the grid of ceiling panels, making the working volume nearly as large as the room.

AN (1) AD-A273 101/XAG
CA (5) APPLIED SCIENCE LABS WALTHAM MA
TI (6) Helmet Mounted Eye Tracking for Virtual Panoramic Display Systems. Volume 2: Eye Tracker Specification and Design Approach.
DN (9) Final rept. Aug 87-Apr 88
AU (10) Borah, Joshua
RD (11) Aug 1989
PG (12) 70 Pages
CT (15) F3361-58-7-C-0542
PJ (16) 7184
TN (17) 26
RN (18) AAMRL-TR-89-019-Vol-2
XC-AAMRL
RC (20) Unclassified report
DE (23) *EYE MOVEMENTS, *HELMET MOUNTED DISPLAYS, *MEASUREMENT
AIMING, AIR FORCE, COCKPITS, COMPUTERS, CUEING, INTERFACES, MAN COMPUTER INTERFACE, MONITORING, OCULOMETERS, PILOTS, PROTOTYPES, REFLEXES, REQUIREMENTS, SELECTION, SWITCHES, TRACKING, VOLUME, IMAGES, COMPUTERIZED SIMULATION, DISPLAY SYSTEMS, VISUAL PERCEPTION
ID (25) PE62202F
AB (27) The virtual cockpit concept being developed by the Air Force will require a helmet mounted eye tracker to be integrated with a helmet-mounted virtual panoramic display (VPD). Eye tracker measurements will be used with prototype systems to assist in candidate display evaluation. Operationally, eye tracking will be used for eye controlled switch selection, cueing, eye-slaved aiming, and pilot state monitoring. Current eye tracking technology is reviewed in Volume I of this report. Relevant physiological considerations and the performance requirements implied by each of the above VPD tasks are thoroughly reviewed in Volume II. A pupil center-to-corneal reflex technique is proposed as the most suitable technique for a VPD eye tracker. The need for robustness and dependability in the virtual cockpit Eye movements, Oculometers, Man-computer interface, Helmet-mounted displays.

AN (1) AD-A308 388/XAG
CA (5) APPLIED SCIENCE LABS WALTHAM MA
TI (6) Helmet Mounted Eye Tracking for Virtual Panoramic Displays. Volume 1: Review of Current Eye Movement Measurement Technology
DN (9) Final rept. Aug 87-Apr 88
AU (10) Borah, Joshua
RD (11) Aug 1989
PG (12) 42 Pages
CT (15) F33615-87-C-0542
PJ (16) 7184
TN (17) 26
RN (18) AAMRL-TR-89-019-VOL-1
XA-AAMRL
RC (20) Unclassified report
DE (23) *COMPUTERIZED SIMULATION, *MAN COMPUTER INTERFACE, *VIRTUAL REALITY, *HELMET MOUNTED DISPLAYS, *EYE MOVEMENTS
TEST AND EVALUATION, CONTROL, REQUIREMENTS, DIGITAL SYSTEMS, MEASUREMENT, OPTICS, AIR FORCE, MONITORING, PERFORMANCE(ENGINEERING), PILOTS, PATHS, TRACKING, PROTOTYPES, PROCESSING EQUIPMENT, DISPLAY SYSTEMS, MOUNTS, EYE, SELECTION, SWITCHES, HELMETS
ID (25) VPD(VIRTUAL PANORAMIC DISPLAY), OCULOMETERS, PE62202F, 13
AB (27) The virtual cockpit concept being developed by the Air Force will require a helmet mounted eye tracker to be integrated with a helmet-mounted virtual panoramic display (VPD). Eye tracker measurements will be used with prototype systems to assist in candidate display evaluation. Operationally, eye tracking will be used for eye controlled switch selection, cueing, eye-slaved aiming, and pilot state monitoring. Current eye tracking technology is reviewed in Volume I of this report. Relevant physiological considerations and the performance requirements implied by each of the above VPD tasks are thoroughly reviewed in Volume II. A pupil center-to-corneal reflex technique is proposed as the most suitable technique for a VPD eye tracker. The need for robustness and dependability in the virtual cockpit application can best be met by using a full two-dimensional solid state array detector and a system that makes the complete image available to a digital processor. Performance goals have been proposed that are feasible and will satisfy the virtual cockpit task requirements. An eye tracker design approach and prototype development plan have been outlined to meet these goals, including as examples, an analysis of possible optical paths for integration with the off-aperture and dual-mirror VPD designs.

AN (1) AD-A203 055/XAG
CA (5) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF ENGINEERING
TI (6) A Helmet-Mounted Virtual Environment Display System.
DN (9) Master's thesis
AU (10) Rebo, Robert K.
RD (11) Dec 1988
PG (12) 87 Pages
RS (14) AFIT/GCS/ENG/88D-17
RC (20) Unclassified report
DE (23) *HELMET MOUNTED DISPLAYS
AIR FORCE, CAMERAS, COLORS, COSTS, DISPLAY SYSTEMS, ELECTROMAGNETIC RADIATION, EQUATIONS, EYE, KALMAN FILTERING, LIQUID CRYSTAL DISPLAY SYSTEMS, MOUNTS, NAVIGATION, OPTICAL IMAGES, OPTICS, PLATFORMS, POSITION(LOCATION), PROTOTYPES, SENSITIVITY, THESES, TRADE OFF ANALYSIS, USER NEEDS, VIDEO SIGNALS
AB (27) This effort researches existing Helmet Mounted Display (HMD) systems and presents a prototype design of a color Helmet-Mounted Virtual Environment Display System. Many existing systems are discussed, including systems currently in use by the US Navy, Air Force, and Army. Several differing designs are presented and evaluated. The Air Force Institute of Technology Helmet Mounted Virtual Environment Display System places the user in an visual situation that is generated by a computer. This HMD system could easily be adapted for use with a video

camera. This paper presents an inexpensive system design that incorporates the benefits of other efforts. The cost trade offs are evaluated and the best design for the lowest cost is presented. The optics, three dimensional considerations, the mounting platform and display technologies are also discussed. The final HMD system design is described in detail and presented so that any reader could build a similar system for minimal cost. This system uses color Liquid Crystal Displays (LCD) mounted directly before the eyes of the user. Specially designed optics were developed to enable the user to focus on the image only inches away. The positional information of the user is determined by a sensitive electro-magnetic device developed by Polhemus Navigational Sciences. This system is very accurate but has a limited effective range. Predictive tracking is discussed and implemented using a simple Kalman filter equation. Theses.

AN (1) AD-A202 303/XAG
CA (5) NAVAL AIR TEST CENTER PATUXENT RIVER MD
TI (6) Development of a Low-Cost Helmet Mounted Eye Gaze Sensor.
DN (9) Technical memo.
AU (10) Dunn, Richard S.
Haspel, Donna L.
RD (11) 27 Oct 1988
PG (12) 33 Pages
RS (14) NATC-TM-88-46-SY
RC (20) Unclassified report
DE (23) *OCULOMETERS, *HELMET MOUNTED DISPLAYS, *STIMULATION(PHYSIOLOGY) AIRCRAFT, BEHAVIOR, COMMERCE, COMPUTER PROGRAMS, CONTRACTS, CYCLES, DEMONSTRATIONS, DETECTORS, DIAMETERS, ENGINEERING, EYE, FLIGHT TESTING, FORMATS, HELMETS, HISTORY, HUMAN FACTORS ENGINEERING, IMAGE PROCESSING, INFLIGHT, LABORATORIES, LOW COSTS, PRODUCTION, PROTOTYPES, SETTING(ADJUSTING), SIMPLIFICATION, TEST AND EVALUATION, TEST EQUIPMENT, TIME, VISUAL PERCEPTION
ID (25) *Eye blink
AB (27) This report documents Phase I of a Small Business Innovation Research (SBIR) contract for development of a low-cost helmet mounted eye gaze point sensor. The device, in completed form, is for use in laboratory, simulator, and in-flight studies by NAVAIRTESTCEN in aircraft test and evaluation projects. Numerous other potential applications in behavioral research and development would benefit from use of the device produces a time history of eye gaze point information along with pupil diameter and eye-blink data. It has flexibility as a sensor system for many different modes of application. Sentient Systems Technology, Incorporated, completed design, testing, prototype hardware and software development, and functional testing of a prototype unit. The effort constituted a full feasibility demonstration in the multistage SBIR contract cycle format. Success in Phase I is intended to lead to follow-on contracts for engineering development and applications development or production during Phases II and III. Functional demonstrations of the prototype unit with Sun Microsystems computer equipment were convincing and fully successful. A complete prototype with simplified software for operation with an IBM compatible PC system is now being evaluated for in-house applications in a behavioral test and evaluation laboratory setting. Keywords: Behavioral test equipment, Eye blink sensor, Flight test equipment, Gaze point sensor, Helmet mounted oculometer, Human factors engineering, Visual processing.

AN (1) AD-B102 897/XAG
CA (5) CAE ELECTRONICS LTD MONTREAL (QUEBEC)
TI (6) Flight Simulator: Wide-Field-of-View, Helmet-Mounted, Infinity Display System.
DN (9) Interim rept. Nov 83-Jun 85
AU (10) Welch,Brian L.
Kruk,Ron V.
Baribeau,Jean J.

Schlef,Charles L.
Shenker, Martin
RD (11) May 1986
PG (12) 168 Pages
CT (15) F33615-81-C-0012
PJ (16) 2143
TN (17) 25
RN (18) AFHRL-TR-85-59
RC (20) Unclassified report
AL (22) Distribution limited to U.S. Gov't. agencies and private individuals or enterprises eligible to obtain export-controlled technical data in accordance with regulations implementing 10 U.S.C. 140c; 9 May 86. Other requests must be referred to AFHRL/TSR, Brooks AFB, TX 78235-5601.
DE (23) *HELMET MOUNTED DISPLAYS, *DISPLAY SYSTEMS, *FLIGHT SIMULATORS
WIDTH, FLIGHT TRAINING, TRACKING, VISUAL PERCEPTION, ACCELEROMETERS, COMPUTER GRAPHICS, IMAGES, BUNDLES, FIBER OPTICS, HEAD(ANATOMY), POSITION(LOCATION), PREDICTIONS, MASS, BACKGROUND, IMAGES, HELMETS, LIGHTWEIGHT, OPTICAL PROPERTIES, STIFFNESS, MODELS, PROTOTYPES, SIMULATION, VISION
ID (25) *Field of view, Visual simulation, Eye slaved displays, EXPORT CONTROL, WUAFHRL27432501, PE62205
AB (27) This report details the continuing development of a fiber optic coupled, helmet mounted display. A prototype model has been developed. A new optical design results in lower mass on the helmet and simplicity of alignment. Techniques for substantially reducing fiber optic bundle mass and stiffness are explored. A dedicated customized helmet has been designed and produced offering a low weight on the head while maintaining the rigidity necessary for good optical performance. Further developments in head position and the use of accelerometers for lead prediction are described. Techniques for blending inset and background images have been developed. Studies have been conducted to validate and optimize display performance. A development program to produce a breadboard helmet mounted eye tracker is in progress. Requirements for a fully eye slaved system are addressed. Keywords: Computer generated imagery; Helmet position sensing; Infinity display; Visual simulation.

AN (1) AD-P010 325/XAG
CA (5) HUMAN FACTORS RESEARCH INST TNO SOESTERBERG (NETHERLANDS)
TI (6) Controlling Unmanned Vehicles: the Human Factors Solution
AU (10) VAN Erp, Jan B.
RD (11) Apr 2000
PG (12) 12 Pages
RN (18) X5-NATO
RC (20) Unclassified report
NO (21) Presented at RTO SCI Symposium on Warfare Automation: Procedures and Techniques for Unmanned Vehicles, Ankara, Turkey, 26-28 Apr 1999. This article is from ADA381871 Advances in Vehicle Systems Concepts and Integration. (les Avancees en concepts systemes pour vehicules et en integration)
DE (23) *HUMAN FACTORS ENGINEERING, *UNMANNED, *COMBAT VEHICLES, *REMOTELY PILOTED VEHICLES
NETHERLANDS, PERFORMANCE(ENGINEERING), GROUND VEHICLES, MAN MACHINE SYSTEMS, DATA LINKS, REMOTE CONTROL
ID (25) COMPONENT REPORTS, NATO FURNISHED, FOREIGN REPORTS
AB (27) Recent developments and experiences have proven the usefulness and potential of Unmanned Vehicles (UVs). Emerging technologies enable new missions, broadening the applicability of UVs from simple remote spies towards unmanned combat vehicles carrying lethal weapons. However, despite the emerging technology, unmanned does not implicate that there is no operator involved. Humans still excel in certain tasks, e.g. tasks requiring high flexibility or tasks that involve pattern perception, and decision making. An important subsystem in which the technology driven aspects and the human factors driven aspects of UVs meet is in the data-link between the remote vehicle and the operator.

The human factors engineer wants to optimize operator performance, which may require a data-link with an extremely large capacity, while other design criteria typically limit the bandwidth (e.g. to lower costs, or because no more bandwidth is available in certain situations). This field of tension is the subject of the present paper. The paper describes two human factors approaches that may help to resolve this field of tension. The first approach is to reduce data-link requirements (without affecting operator performance) by presenting task-critical information only. Omitting information that is not needed by the operator to perform the task frees capacity. The second approach is to optimize performance by developing advanced interface designs which present task-critical information without additional claims on the data-link. An example will be given of both approaches.

AN (1) AD-A302 528/XAG
CA (5) SRI INTERNATIONAL MENLO PARK CA
TI (6) Advanced Telepresence Surgery System Development
AU (10) Shah, Ajit
RD (11) 06 Dec 1995
PG (12) 13 Pages
CT (15) DAMD17-95-1-5019
RN (18) XA-USAMRMC
RC (20) Unclassified report
DE (23) *COMPUTERIZED SIMULATION, *MAN MACHINE SYSTEMS, *MEDICAL SERVICES, *SURGERY, *SERVOMECHANISMS, *MICROSURGERY
CONTROL, ELECTRONICS, WARFARE, CONTROL SYSTEMS, MODELS, ARMY PERSONNEL, INTERFACES, MEDICINE, WOUNDS AND INJURIES, ANATOMICAL MODELS
DC (24) (U)
ID (25) *TELEPRESENCE SURGERY, TSW(TELEPRESENCE SURGEON'S WORKSTATION)
IC (25) (U)
AB (27) SRI International is currently developing a prototype remote telepresence surgery system, for the Advanced Research Projects Agency (ARPA), that will bring life- saving surgical care to wounded soldiers in the zone of combat. Remote surgery also has potentially important applications in civilian medicine. In addition, telepresence will fmd wide medical use in local surgery, in endoscopic, laparoscopic, and microsurgery applications. Key elements of the telepresence technology now being developed for ARPA, including the telepresence surgeon's workstation (TSW) and associated servo control systems, will have direct application to these areas of minimally invasive surgery. The TSW technology will also fmd use in surgical training, where it will provide an immersive visual and haptic interface for interaction with computer-based anatomical models. In this paper, we discuss our ongoing development of the MEDFAST telesurgery system, focusing on the TSW man-machine interface and its associated servo control electronics.

AN (1) AD-A303 353/XAG
CA (5) MASSACHUSETTS INST OF TECH CAMBRIDGE DEPT OF AERONAUTICS AND ASTRONAUTICS
TI (6) Evaluation for Vibrotactile Systems in Helicopter Hover and EVA environments.
DN (9) Quarterly rept. 1 Sep-30 Nov 95
AU (10) Newman, Dava J.
RD (11) 18 Dec 1995
PG (12) 5 Pages
CT (15) N00014-95-1-1312
RN (18) XB-ONR
RC (20) Unclassified report
DE (23) *BIBLIOGRAPHIES, *HELICOPTERS, *GLOBAL POSITIONING SYSTEM, *INERTIAL NAVIGATION, *EXTRAVEHICULAR ACTIVITY
TEST AND EVALUATION, FLIGHT TESTING, VIBRATION, MILITARY PERSONNEL, INTEGRATED SYSTEMS, ACQUISITION, FLIGHT CONTROL SYSTEMS, KALMAN FILTERING, TRACKING, MAN MACHINE SYSTEMS, FLIGHT PATHS, HOVERING, TOUCH
AB (27) The vibrotactile (VT) advanced technology demonstration (ATD)

introduces a novel human-machine interface, namely, haptic stimulation through a VT suit to improve military personnel performance. The complete vibrotactile (VT) suit system will include three main components: a sensor package to acquire motion and orientation information, a control computer that will condition and convert the sensor information into output drive signals, and the VT suit for the test pilots. Design solutions for a navigation sensor package to be used in helicopter hover and extravehicular activity (EVA) environments is currently being undertaken. Integrating an Inertial Navigation System (INS) with the Global Positioning System (GPS) has provided numerous benefits, and with the recent advances in Kalman filtering techniques, the number continues to grow. In addition to increased navigation accuracy under dynamic conditions, tracking accuracy has improved, CPU time has decreased and crew workload has decreased. The dual 1N/GP system has already proven its strength in a variety of capacities such as helicopter flight path control, flight path management, flight testing and helicopter approach. While research efforts continue to establish a portfolio for this dual system, much of the present attention had been given to reducing the development and acquisition costs.

AN (1) AD-A258 048/XAG
CA (5) ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT NEUILLY-SUR-SEINE (FRAN CE)
TI (6) Advanced Aircraft Interfaces: The Machine Side of the Man-Machine Interface (Les Interfaces sur les Avions de Pointe: L'Aspect Machine de l'Interface Homme-Machine).
DN (9) Conference proceedings.
RD (11) Oct 1992
PG (12) 342 Pages
RS (14) AGARD-CP-521
RN (18) X5-XD
RC (20) Unclassified report
NO (21) Text in English and French.
DE (23) *FLIGHT CONTROL SYSTEMS, *MAN MACHINE SYSTEMS, *SYMPOSIA VISUAL PERCEPTION, AUDITORY PERCEPTION, TOUCH, VOCODERS, HELMET MOUNTED DISPLAYS, DATA DISPLAYS, PILOTS, JOB ANALYSIS, WORKLOAD
ID (25) NATO Furnished, Voice activation
AB (27) This Symposium explored the use of three of man's senses (sight, hearing, touch) to improve the man-machine interface in the cockpit. The seven sessions included Defined Concepts and Design Issues, Maintenance for Advanced Cockpit Systems, Panoramic and Virtual Cockpits, Helmet Mounted Displays, Voice Technology, System Concepts and Design Tools, and finally Device Technologies. As the demands placed upon the aircrew by the modern battlefield continue to increase, this Symposium attempted to effectively blend the technologies is available to decrease the workloads.

AN (1) AD-A257 998/XAG
CA (5) BBN SYSTEMS AND TECHNOLOGIES CORP CAMBRIDGE MA
TI (6) Usable, Real-Time, Interactive Spoken Language Systems.
DN (9) Annual rept. 1 Oct 91-30 Sep 92
AU (10) Makhoul, John
Bates, Madeleine
RD (11) 30 Sep 1992
PG (12) 9 Pages
CT (15) N00014-92-C-0035
RN (18) XB-ONR
RC (20) Unclassified report
DE (23) *MILITARY RESEARCH, *SPEECH RECOGNITION, *MAN COMPUTER INTERFACE OPERATIONAL EFFECTIVENESS, HUMAN FACTORS ENGINEERING, COMPUTER LOGIC, PROCESSING, ALGORITHMS, NEURAL NETS, VOCABULARY
AB (27) To adapt to the requirements posed by rapidly changing world-wide threats, modern military systems must harness advanced technology in

ways that significantly improve operational effectiveness. Many critical systems are interactive, and the ability of user to interact with such systems could be improved by the addition of spoken language interfaces to facilitate human/machine interaction, increase productivity, and reduce training time. Our goals are to develop usable SLSs that exhibit the following advances: (1) at least an order of magnitude increase in speed, with higher accuracy; (2) a four-fold reduction in the overall understanding error rate; (3) a vocabulary of up to 10,000 words; (4) a highly interactive user interface capable of mixed initiative; dialogue, system feedback, and user corrections and additions; (5) a flexible system capable of transparently adapting to a new user; (6) a modular system easily portable to new applications and sites; and (7) a system implementable in real-time on COTS hardware.

AN (1) AD-B158 672/XAG
CA (5) FOREIGN TECHNOLOGY DIV WRIGHT-PATTERSON AFB OH
TI (6) Weapon and Technology Cockpit: Future Fighters and Pilots Equipped with the Feature of Advanced Technologies
AU (10) Hamada, Ichiho
RD (11) 16 Jul 1991
PG (12) 21 Pages
RS (14) FTD-ID(RS)T-0308-91
RN (18) XF-FTD
RC (20) Unclassified report
NO (21) Trans. of Gunji-Kenkyu (Japan) n6 p92-102 1987.
AL (22) Distribution authorized to U.S. Gov't. agencies and their contractors; Copyright, Specific Authority; 27 Aug 91. Other requests shall be referred to FTD/STINFO, Wright-Patterson AFB, OH 45433.
DE (23) AIRCRAFT, AIRFRAMES, COCKPITS, ERGONOMICS, HUMAN FACTORS ENGINEERING, INTERFACES, JET FIGHTERS, PILOTS
ID (25) *Cockpits, *Interfaces, *Man machine systems, Japan, Japanese language, Translations
AB (27) A cockpit is mans workshop and the only interface with a machine (aircraft) . Without considering such concepts as ergonomics or human engineering it is understood that it depends on the cockpit to make the most of the capability of an airframe and a pilot.

AN (1) AD-A246 800/XAG
CA (5) MASSACHUSETTS INST OF TECH CAMBRIDGE RESEARCH LAB OF ELECTRONICS
TI (6) Auditory Localization in Teleoperator and Virtual Environment Systems: Ideas, Issues, and Problems
AU (10) Durlach, Nat
RD (11) 1991
PG (12) 13 Pages
CT (15) AFOSR-90-0200A
PJ (16) 2313
TN (17) A9
RN (18) AFOSR-TR-92-0066
XF-AFOSR
RC (20) Unclassified report
AL (22) Availability: Pub. in Perception, v20 p543-554, 1991. Available to DTIC users only. No copies furnished by NTIS.
DE (23) ENVIRONMENTS, HAZARDS, HUMANS, INTERFACES, MAN MACHINE SYSTEMS, OPERATORS(PERSONNEL), ROBOTS, SENSES(PHYSIOLOGY), TELEOPERATORS
ID (25) PE61102F, WUAFOSR2313A9, Reprints
AB (27) The increasing availability and use of advanced high tech human machine interfaces raise many interesting questions about what information should be presented to each sensory modality and how the information should be coded for a given modality. In this paper, attention is confined to the auditory component of the interface and, more specifically, to auditory localization. Both teleoperator systems and virtual-environment systems are considered, and attention is focused upon the opportunities and difficulties associated with the use of unnatural perceptual cues in these systems. Of central interest in this discussion is the use of such cues to improve resolution and thereby

obtain systems with superlocalization capabilities. Advances in technology are creating major new challenges in the area of human machine interfaces and, in particular, the design of interfaces for teleoperator systems and virtual environment systems. In a teleoperator system, the human operator senses and operates upon a remote, inaccessible, or hazardous environment by means of a slave robot. Signals in the environment of the robot are sensed by devices on the robot, communicated back to the teleoperator interface, and displayed to the human operator; the responses of the human operator are sensed by devices at the interface, are communicated back to the robot, and are used to control the actions of the robot.

AN (1) AD-A294 039/XAG
CA (5) NAVAL RESEARCH LAB WASHINGTON DC
TI (6) Eucalyptus: An Integrated Spoken Language/Graphical Interface for Human-Computer Dialogue.
AU (10) Wauchope, Kenneth
RD (11) 1991
PG (12) 12 Pages
RN (18) XB-NRL
RC (20) Unclassified report
DE (23) *INTERACTIVE GRAPHICS, *MAN COMPUTER INTERFACE, *VOICE COMMUNICATIONS TEST AND EVALUATION, COMPUTERIZED SIMULATION, TRAINING DEVICES, HUMANS, INTERACTIONS, TOOLS, TRACKING, PLANNING, USER NEEDS, KNOWLEDGE BASED SYSTEMS, SPEECH, NATURAL LANGUAGE
DC (24) (U)
AB (27) As more and more machine intelligence is built into the interactive software tools of the future, the more the human-computer"dialogue" may come to resemble a true human-human dialogue, each party anticipating information needed by the other and avoiding rigid, repetitive or overly detailed exchanges by assuming the existence of a body of shared contextual knowledge. Although to humans dialogue means primarily natural language (NL) communication, friendly and effective human-computer dialogue should be able to take full advantage of an integrated mix of several different interaction modes including keyboard, speech, graphics, and body gestures. Context tracking would allow each input or output transaction to be minimally specific, deriving its full interpretation from background information relevant to the current topic of the interchange. The U.S. Navy has a particular interest in developing advanced user interfaces to such interactive knowledge-based tools as decision support systems, expert systems, and training aids. As a testbed for an initial investigation of integrated NL/graphical interfaces to such systems, we have been working for about a year now with a simulation-based test planning tool developed by Los Alamos National Laboratory for the Naval Air Systems Command. (KAR) P. 2

AN (1) AD-P005 602/XAG
CA (5) ROYAL AIRCRAFT ESTABLISHMENT BEDFORD (ENGLAND)
TI (6) The Flight Evaluation of a Speech Recognition and a Speech Output System in an Advanced Cockpit Displays and Flight Management System for Helicopters
AU (10) Little,R.
RD (11) Feb 1987
PG (12) 12 Pages
RC (20) Unclassified report
NO (21) This article is from 'Information Management and Decision Making in Advanced Airborne Weapon Systems: Conference Proceedings of the Aerospace Medical Panel Symposium Held in Toronto, Canada on 15-18 April 1986,' AD-A184 044, p28-1-28-12.
DE (23) *AVIONICS, *SPEECH RECOGNITION COCKPITS, HELICOPTERS, FLIGHT TESTING, INTERFACES, DIGITAL MAPS, CATHODE RAY TUBE SCREENS, COLORS
ID (25) *Speech output, Component Reports, NATO furnished

AB (27) A Wessex helicopter at RAE Bedford has been used to develop and evaluate a set of electronic cockpit displays and a comprehensive suite of avionics which were integrated to form an advanced display and flight management system for both military and civil applications. Two important features of the system were automatic speech recognition and synthetic speech output. Flight trials have been conducted to determine the ground rules and principles pertinent to the successful integration of these devices with other advanced avionics. The trial has shown that the combination of speech recognition and synthetic voice systems offers an element of redundancy and if correctly integrated into the cockpit will be capable of improving the man machine interface to a far greater degree than is achievable by hand or voice alone. (Author)

AN (1) AD-A187 074/XAG
CA (5) ROYAL AIRCRAFT ESTABLISHMENT FARNBOROUGH (ENGLAND)
TI (6) A Flight Evaluation of Voice Interaction as a Component of an Integrated Helicopter Avionics System.
DN (9) Technical memo.
AU (10) Little, R.
Cowan, R.
RD (11) Apr 1986
PG (12) 43 Pages
RS (14) RAE-TM-FS(B)-637
RN (18) DRIC-BR-100581
RC (20) Unclassified report
DE (23) *AVIONICS, *MANAGEMENT PLANNING AND CONTROL, *SPEECH RECOGNITION, *GREAT BRITAIN
AUTOMATIC, COCKPITS, COLORS, DATA PROCESSING, DIGITAL MAPS, DISPLAY SYSTEMS, FLIGHT, FLIGHT TESTING, HELICOPTERS, INPUT, INTEGRATED SYSTEMS, INTERACTIONS, INTERFACES, MAN MACHINE SYSTEMS, MILITARY APPLICATIONS, OUTPUT, OVERLAYS, REDUNDANCY, SPEECH, SYNTHESIS, TEST AND EVALUATION, TOUCH, VOICE COMMUNICATIONS
ID (25) *Synthetic speech, *Voice interaction
AB (27) A Wessex helicopter at RAE Bedford was used to develop and evaluate an integrated avionics system which incorporated advanced displays and a flight management system for both military and civil applications. Two important features of the system were automatic speech recognition and synthetic speech output. Flight trials have been conducted to establish guidelines for the successful integration of these devices with advanced avionics such as colour displays, digital maps and touch overlays. The use of speech technology in the cockpit offers an element of redundancy and if correctly integrated will be capable of improving the man machine interface to a far greater degree than is achievable by hand or voice alone. The trial has shown that data input and retrieval from such a well structured cockpit management system can be achieved quickly, simply and easily. Keywords: Speech recognition; Flight evaluation; DVI. Speech output; Advanced Avionics; Helicopters; Great Britain.

AN (1) AD-A119 559/XAG
CA (5) ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT NEUILLY-SUR-SEINE (FRANCE)
TI (6) Advanced Avionics and the Military Aircraft Man/Machine Interface.
DN (9) Conference proceedings.
RD (11) Jul 1982
PG (12) 342 Pages
RS (14) AGARD-CP-329
RC (20) Unclassified report
NO (21) Presented at the Meeting of the Avionics Panel, 26-29 Apr 82, Blackpool, UK. Text in English and French.
DE (23) *Military aircraft, *Avionics, *Man machine systems
Display systems, Colors, Speech recognition, Speech representation, Synthesis, Input output devices, Computers, Flight crews, Voice communications, Symposia, Reports, Panel(Committee)
ID (25) NATO furnished

AB (27) These Proceedings consist of the papers and discussions presented at the Avionics Panel Meeting on 'Advanced Avionics and the Military Aircraft Man/Machine Interface' held in Blackpool, England, 26-29 April 1982. The 30 papers presented were divided as follows: three were introductory, 5 were on Colour Display Systems, 9 were on Voice Input and Output Systems, 6 were on Aircrew Interaction with Complex Systems, and 7 were on Display Technology. The Proceedings also include a Technical Evaluation Report of the Meeting. (Author)

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